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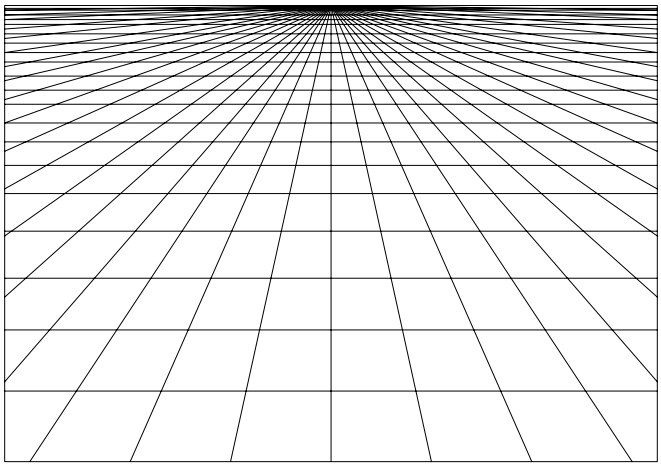

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Diffusion of EU- funded Research Results: The Role of Internal Determinants

Susanne Skagen Breum
University of Oslo / Lund University
Supervisor: Carl- Magnus Pålsson
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However, only I am responsible for the contents of this thesis and all potential errors are mine, and mine alone.

Susanne Skagen Breum (Sign.)

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Abstract

As its point of departure this paper takes that diffusion of research results stemming from EU funded research consortia might face greater challenges than other collaborations due to the way diffusion to a higher extent depends upon the members' faith in and motivation for further development. The paper therefore emphasises the role of internal determinants in processes of diffusion.

Based on a case study of the research consortium LowHeat, the paper tries to go back in the process of innovation and study how the consortium has worked together and how their perceptions of LowHeat are as the project is approaching its closure. With a reference to the Actor-Network Theory the study also includes how non-human actors like time, motivation and language have affected the innovation process and the members' understanding of LowHeat. The main theoretical references however, are made to theories on innovation and diffusion combined with communication theories. This theoretical framework underlines the paper's focus on interaction, communication and understanding in innovation processes as it is the researcher's belief that internal processes in consortia might be more important in regards of diffusion than previous studies have focused on.

Although new network connections and exchange of knowledge is a valuable outcome from collaborative projects, diffusion of the results is the primary goal of projects funded by the EU. This paper therefore argues that a higher focus placed on attracting motivated project members and keeping them motivated and committed to the project might prove valuable for future research consortia.

Keywords: Diffusion, Framework funded research projects, Internal determinants, Innovation, Communication

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Chapter 1: Introduction

"There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things"

Machiavelli (1950:21-2)

1.1 Innovation and diffusion - a necessity

As this quote points out, it can be both difficult and risky to do something different, to initiate something new. Nevertheless, despite the difficulties, risks and dangers related to them, the new political structures Machiavelli referred to were regarded as necessities. The same necessity can apply in respect of innovations which are defined as "new combinations of existing resources" (Fagerberg et.al 2005:6). A common perception nowadays is that innovativeness is a supposition for economic growth and success for all types of societies; either it is a continent, country, region, sector or an organization.

However, in order to obtain economic growth from innovations, they have to be adopted and used by others. Making new knowledge available and applicable is thus what cause revenue on investments put in research. Furthermore, the access to knowledge can breed new knowledge and stimulate other innovations (Fagerberg et. al 2005, Kline and Rosenberg 1986). This can only take place if the innovations are spread, which is referred to as diffusion. Diffusion is thus a key element in any process of innovation.

Investing in innovations

Innovations can emerge from coincidences; people finding more efficient ways of working or accidents leading to scarce resources and forcing changes. It can also be a way of imitating others who have had success with something. Furthermore, innovations can be a planned action to increase efficiency or competitiveness. Such latter cases often seem to be the results of investments in research.

Even though no direct line between research investments and innovations has been proven, many innovations emerge from research, a causal chain often referred to as "the linear model" (Fagerberg et. al 2005). A positive correlation between research and development and output in growth has also been shown (EIU 2007). However, hardly all research investments end up causing an economic surplus which explains why research investments are risky as they can never guarantee economic revenue[1]. At the same time, investments in research and development have turned out to be both time consuming and costly. "An invention that costs US$1,000 to make can easily cost US$ 10 millions to turn into an innovation" (EIU 2007:7). It might thus take many years from an investment is made until an invention is developed. Innovations therefore depend on people willing to invest their time, money and effort in "prototype construction, financing, customer demonstration, field trials, engineering, production, marketing and finally sales" (EIU 2007:7).

[1] Terms like "The Norwegian paradox" and "The Swedish paradox" are often used to give examples where the correlation between research investments and economic growth has been low, referring to the two economies' differences in both investments in research and gross domestic product (GDP). Whereas Norway has invested a small share of their GDP in research but still experienced high economic growth, the opposite has been the case in Sweden.

Innovation and alliances

When facing these challenges regarding research investments while at the same time appreciating the necessity of being innovative, one solution for many organizations has been the establishments of collaborative alliances (Tidd et al. 2005). This can be especially useful for a small and medium-sized enterprise (SME) who might "lack the necessary financial, technological and human resources to proceed (research) by itself" (Euroabstacts 4/06). Knowledge of this has led governmental institutions like the European Union (EU) fund the establishment of consortia, allowing SMEs to invest time and effort in research without taking great economic risks (Tidd et. al 2005). This is known as the EU's framework programme. The research consortia will therefore be referred to as "framework funded" in this context.

In consortia, different participants from a certain sector agree on a temporary partnership to develop new knowledge and an invention which the involved SMEs and industrial association groups may exploit to strengthen their competitive advantage in future operations. If the partners succeed in making a product or a solution that is adopted by others, they turn an invention into an innovation. As stated by one of the official journals for the European Communities, this is the purpose of the funded consortia's research results:

> "The participants and the Community shall use or cause to be used the knowledge which they own arising from the direct actions or indirect actions, in accordance with the interests of the participants concerned."
>
> (European Community Regulation 2002, article 23 - 1)

> "If dissemination[2] of the knowledge does not adversely affect its protection or use, the participants shall ensure that it is disseminated within a period laid down by the Community"
>
> (European Community Regulation 2002, article 23 - 2).

Not all consortia however, end up diffusing their results, although the collaborations might have been successful. This matter, which will be explored in this paper, can serve as an illustration of the existence of controversies regarding the achievements of such EU programs, as pointed out by Pavitt (2005).

Internal determinants and the process of diffusion

Due to the importance of diffusion many studies have been done to see what stops the diffusion process, what enhances it and why some inventions are more easily adopted than others (see Rogers 2003). The *external* determinants for diffusion, meaning factors outside the actual creation of the innovation that affects the diffusion of it have thus been in focus. Examples of such determinants might be the economy, trends, competing products or the lack of meeting a societal need.

However, factors inside an innovation process may also affect the diffusion of the planned invention as the diffusion depends upon people willing to put a high effort in turning the invention into an innovation. The point of departure in this paper is that such internal determinants might be especially important in cases of framework funded research since the

[2] According to Rogers (2003) the difference between dissemination and diffusion is a matter of whether the spread is planned or un-planned. As all consortia have guidelines and plans for spreading their results, the EU use the word dissemination. Dissemination is however still diffusion and as this paper will be based on general innovation theory, the term diffusion of innovations will be applied.

diffusion of the results depends to a higher extent upon the partners' ambitions regarding further development after the funded period. A study of *internal* determinants for diffusion therefore seems both actual and interesting since the number of collaborative innovation projects is increasing (EIU 2007). In order to explore the role of internal determinants, an EU funded research consortium called LowHeat will be used as a case when studying:

> How can internal factors in a framework funded collaborative innovation process impact the partners' understanding of the artefact that is being made and in turn affect the diffusion of it?

The objective for applying this research question to a case study is to provide a description of, and to place a focus on how internal determinants can affect the diffusion of innovations by influencing the partners' understanding of the innovation itself and the process. By doing so, the paper aims to illustrate the controversies regarding how an invention, shaped and created within the small societal frames to a consortium, can be made into an innovation that is adopted and used by others. The internal determinants that will mostly be emphasised are language, time and motivation.

As implied by the research question, this paper will focus on communication processes, the establishment of trust among actors and how a mutual understanding is created within the consortium. This choice of focus might be explained in the following way:

1) When joining a funded research project, the economic risk is small. Further development does however demand personal investment. Diffusion of research results from framework funded collective research projects might therefore face greater challenges

than other collaborations due to diffusion not being a matter of course, but depends upon the members sharing a faith in and motivation for further development of the project.

2) A mutual understanding of the artefact is necessary for anyone to correctly discuss and decide upon a new idea. Thus without a mutual understanding within the consortium, fruitful interactivity that can enhance the innovation might not take place. Each partner's understanding of the artefact will also affect their consensus on whether to accept it or not. It seems only logical that if the consortium members' understanding of the artefact does not make them accept it, the external environment is unlikely to adopt it as well.

3) Relations of trust are crucial for interaction and good communication to take place, which in turn is needed for a mutual understanding to be established. Consortia might face greater challenges here as they have different nationalities and cultures, they usually do not know each other prior to the project and they might have different reasons and objectives for taking part.

1.2 Structure of the thesis

This introduction has hopefully given a thorough background for the chosen topic. In the following chapter, the LowHeat case will be presented. The theoretical framework within which the study is performed is given in the third chapter where theories about innovations and literature on why firms collaborate in innovation processes will be described further. Moreover, the chapter will present theories on organizational communication before a summary is given of some literature regarding diffusion of innovation.

The methodological approach in the fourth chapter and will describe how LowHeat has been studied. This case study approach mainly consists of a survey, observations and

informal conversations with the partners. The consortium was established three years ago to invent and develop a solution that could extract heat energy from waste water and use it for heating new water. At the time of study, the consortium is approaching the final stage of the project and has come to the point where exploiting and diffusing the research results are the next steps. However, as the empirical findings presented in the fifth chapter will show, not all partners are as eager as others to continue with the project even though the consortium has managed to create an artefact as intended. The chapter will use the study of internal determinants within the consortium as a point of departure to illustrate possible reasons why this might be the case. The paper finishes with a conclusion and some suggestions for further research.

1.3 Scope and limitations

It remains an issue that a single case study can not be used to make general conclusions on how internal processes impact the processes of diffusion. Moreover, the research has been performed within a limited time period. Nevertheless, this paper provides an analysis and description of the internal processes taking place within a consortium. The role understanding, communication and interaction play in regards to diffusion is therefore emphasised.

Chapter 2: The case of LowHeat

LowHeat is a so called collective project funded by the European Commission's (EC)[3] 6th Framework Programme (FP6) for research and development. The framework programme

[3] As EC is an institution within the European Union (EU), this paper does not distinguish between EU and EC.

supports a wide range of research activities, usually divided between collective or co-operative research projects. "Collective research projects are larger and usually run longer than co-operative research projects"[4]. Moreover, collective research is "research performed for the benefit of a broad target group ("community") of firms. The research results are accordingly disseminated widely" (Luktvasslimo 2007:7). Lowheat is funded under a special FP6 instrument called "Research for the Benefits of groups of SMEs", with several Industry Association Groups acting on behalf of the SMEs interests and disseminating the results widely to their members. At the time of study, the European Commission is funding 52 collective research projects where LowHeat is one of them. In order to get funds, the consortia go through a strict process of applications. When approved, it is demanded that the consortia follow guidelines laid down by the European Commission.

Like other collective research projects, LowHeat has an overall goal of creating solutions that both increase the competitiveness of a particular branch within the European Union (EU) and create benefits for the Community as a whole. The initial aim thus differs from that of co-operative research which seeks direct benefits for the members within the consortium. However, LowHeat can be regarded as a hybrid between the two types of consortium as their objective is to provide a competitive advantage for the consortium members as well. This makes LowHeat a solid case for studying internal determinants for diffusion of EU funded research results as it has traits of both types of consortia.

All collaboration projects funded by the EC consist of research performers (RTD), Industrial Association Groups (IAGs) and small and medium sized enterprises (SMEs). The objective is, as in any collaboration, to benefit from each others' knowledge and network and use this to innovate. The SME's know the status of the branch; they know what is needed and

[4] Direct quote from http://sme.cordis.lu/collective/infobrochure.cfm (downloaded September 4th 2007).

how to implement a certain solution. Moreover, they have expert knowledge on certain elements needed in the technology. The research performers have the knowledge to develop the technology while the Industrial Association Groups have the network and ability to transfer the knowledge on to their members.

As illustrated in table 1 (see next page), the nationalities participating in the study are Spanish, English, Norwegian and Polish. The representatives from Germany and Ireland did not attend the first consortium meeting where the survey took place. They did however attend the meeting three months later. Their impressions have thus contributed to the study as well. All different types of partners were present; research performers, industrial association groups and SMEs. The Institute of Plumbing (IOP) took the initiative to establish the consortium, and function as the project's owner. They have however delegated administrative aspects and the role as project manager to PERA.

The consortium partners have stated that their main goal has been to:

> "Develop a low grade heat exchanger for use in the domestic sector to recover over 40% of the heat energy from this waste water to supplement domestic boilers. In so doing we aim to reduce the overall energy consumption of domestic dwellings by 7%" [5]

The technology behind this low grade heat exchanger is what is referred to as *the artefact* throughout this paper.

[5] From the project's "Description of Work", p. 3. Internal document issued December 2003. It has never been published, but was provided to this study by the National Institute of Technology (Teknologisk Institutt AS).

No.	Name	Type of member	Country
1	Institute of Plumbing	IAG	United Kingdom
2	Polska Korporacja Techniki Sanitarnej Grzewczej Gazowei limatyzacij	IAG	Poland
3	PERA	RTD	United Kingdom
4	Teknologisk Institutt AS	RTD	Norway
5	AIMPLAS	RTD	Spain
6	CRS	SME	United Kingdom
7	AK Industries Limited	SME	United Kingdom
8	Convex Electrical	SME	Ireland
9	*Metallisation Limited*	*SME*	*United Kingdom*
10	K Lund AS	SME	Norway
11	Angewandte System Technik	SME	Germany
12	R Prettie & Co limited	SME	United Kingdom

Table 1: The 12 members of the LowHeat consortium. Metallisation Ltd. did not participate in the survey at all.

At the time of study, the consortium has successfully achieved the goal of developing the technology. This is why the consortium is an interesting case as the research result itself might not be what decides the diffusion, but rather other factors. The solution is meant to be commercialized and used to strengthen the plumbing sector within the EU as LowHeat covers what the project members believe is an unmet need for recycling of waste water. However, the pay back time from applying the heat exchanger for domestic use turned out to be too

long. The consortium therefore agreed earlier in the process that the solution should be for industrial use where the volumes of waste water are higher. Potential users might be owners of large buildings such as laundries, training centers and hotels. New directives within the EU regarding more energy efficient buildings and reduction of CO2 emissions support the timing for LowHeat. Increased energy prices and environmental consumer awareness are other factors that might enhance the uptake of the technology.

A potential uptake does however presuppose that the members are willing to continue the development after the project's formal end. Only if the development reaches that point will the research be diffused. To date, the consortium has submitted a patent application and they have been in contact with some potential investors as well.

The SME partners of LowHeat are now in the process of making the decision on whether to continue with the project or not. If they do continue, they will collaborate with the other SMEs without the coordinating role of the IAGs. The RTDs will no longer be there to explain how the technology works, either. More importantly they will have to proceed without funds from EU. Investing their own money increases the risks. It is therefore of interest to see how they regard the collaboration, how this has influenced their understanding of LowHeat, meaning both the artefact itself and the other members, as the diffusion of their research results depends upon these factors.

Chapter 3: Theoretical framework

This chapter aims at presenting a theoretical framework within which the case study will be made. It also seeks to provide definitions on the vocabulary used, as many of the applied words might have different interpretations in different contexts.

Chapter overview

The chapter will be divided into four main sections. After a short introduction of definitions, it will begin with a description of some theories of innovation to explain the importance of innovation and why firms collaborate in innovations.

The way of studying different actors' influence on innovation processes is an expression of social constructivism which sees science and technology as socially constructed (Bijker et al. 1987). The core in social constructivism is the way innovation depends upon social processes. As this is the notion upon which this paper is built, social constructivism will be briefly elaborated in the second section. So will the actor-network theory (ANT) which is a tool[6] deriving from theories of social constructivism. In this paper ANT will be used as a way to describe how the interaction between different actors affects the process of innovation by either enhancing or hindering the creation of a mutual understanding. ANT is an interesting tool in this study due to the way ANT encompasses all that has an impact on the science as an actor, even non-humans. One of the main authors behind ANT, Bruno Latour, states this concisely as "actors are units that do something" (Latour 1992:241 in Stalder 1997). The internal determinants mentioned in the introduction, namely time, language and motivation will therefore in this study be regarded as non-human actors.

In order to explore group related processes that matter for collaborative innovation projects, theories on communication in organizations and organizational behaviour will be presented in the third section, focusing on the importance of trust among actors, face-to-face interaction and the creation of a mutual understanding. The emphasis will lie on the works of

[6] Although the word "theory" is a part of the term ANT, Callon, one of the main men behind ANT, writes that it is not a theory, but more a method giving ANT a wide area of use and adoption (Hassard and Law 1999). Due to this, the focus in this paper is of ANT as a tool.

the Norwegian professor in Psychology, Carl E. Grenness (2002) although other authors will shed light on the subject as well.

The fourth and final part of the literature review will present theories regarding diffusion of innovations, mostly focusing on the works of E.M Rogers (2003) where communication plays an important role. The way of separating diffusion from the theories of innovation is a paradox due to the way the dynamics of innovation processes in which diffusion is a key element is stressed throughout the paper. The separation is however made because diffusion is a core topic.

In "Diffusion of Innovations" Rogers (2003) presents a model for innovations and decision making to create understanding on how each possible adapter goes through a process before choosing to implement the new. It will be the argument in this paper that such a process is valid for members of a consortium as well, as they have to understand and be convinced about the invention in order to wish to develop it further. The emphasis in this section, as for the whole paper, will thus lie on a mutual understanding among the creators and close ties to others and the invention as suppositions for turning an invention into an innovation; thus diffusing it.

Core definitions and concepts

The topic of diffusion is the general core of this paper and most of the theory stems from the works of Rogers (2003). Rogers defines diffusion as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 2003:5). As Rogers focus on the spread of an innovation in general, the definition covers all types of diffusion meaning both the spread of an innovation from one context to another and the spread of an invention leading to adoption and thus making it an innovation.

This paper will take only the latter as its point of departure and see diffusion as the process that turns an invention into an innovation. This is in line with the definition of Bronwyn H. Hall who sees diffusion as "one of three pillars on which the successful introduction of new products, processes and practices into society rests, along with invention (…) and commercialization (…)" (Hall 2005:478). In this study of LowHeat, diffusion will thus be regarded as future activities possibly leading to the spread, implementation and adoption of the invention LowHeat. The element of commercialization is left out of the study, but can in this context be seen as a part of the diffusion.

Other concepts that are regularly used and should be defined are interaction, actor, understanding and communication. *Interaction* in this context refers to the influence of objects, materials, or events on one another, meaning any type of activity or intervention between two or more actors. As presented previously, an *actor* is any unit that does something in the creation of something new. Through that, the actors influence the outcome, or other actors' understanding of the outcome. The term *understanding* will be defined here as a mode where one has the feeling of adequate knowledge about something and is able to see the meaning behind it, develop an opinion about it and able to communicate this further.

Communication is also defined in many ways in different literature. A technical description of communication applied to this paper is "transport or procurement of energy and information over or through a limit between two or more systems" (Grenness 2002:12). This wide definition is suitable for the purpose of this thesis, as the definition covers both verbal and non-verbal action and does not differentiate between human and non-human actors. Thus a ticking clock communicates time going by, persons' way of sitting around a meeting table communicates their degree of interest, the tone of the voice with which information is shared can communicate the mood of a person, and so on. Often, more than one type of

communication is manifested at the same time, thus enhancing the message that is sent (Grenness 2002).

3.1 Innovation theories and models

One of the first theorists on innovations was the evolutionary economist Josef Schumpeter (1883-1950) who defined innovation as "new combinations of existing resources" (Fagerberg et. al 2005:6). Schumpeter saw economic development as "a process of qualitative change, driven by innovation" (Fagerberg et. al 2005:6). This means that although many inventions are implemented, only the ones which happen to improve a society or are best fitted to the environment, survive. Furthermore, Schumpeter emphasised the importance of other incremental innovations occurring while an invention was in its phase of diffusion. When a new invention is appreciated, new ideas are emerging on how to improve the existing invention or how to apply it. It therefore seems as if the early works of Schumpeter regarded the process of innovation as dynamic.

In 1945 Vannevar Bush published the report "Science: the endless frontier" in which he argued for higher investments in research and development to increase economic growth. Bush's article was later used as a policy document, supporting arguments for higher governmental investments in research (Borràs and Lundvall 2005). His arguments were based upon research leading to development which in turn could foster a solution to cover an unmet need. Such a way of describing an innovation process as a chain of causation is often labelled "the linear model" (Fagerberg et. al 2005). The term was further discussed by Kline and Rosenberg in the article "An Overview of Innovation" (1986). Kline and Rosenberg argue that only a minority of innovations occur in line with the linear model as "firms mostly innovate because they believe there is a commercial need for it" (Fagerberg et. al 2005:9). Moreover, the linear model fails to include the many feedbacks and loops that take place

during the process of innovation which can lead to a reconsideration of earlier steps. This reconsideration might, as also described by Schumpeter, lead to totally new innovations (ibid). As mentioned in the introduction, diffusion of knowledge and innovation is thus also important because it breeds new innovations and new knowledge.

Rosenberg stressed this matter already four years earlier in his article "Learning by using" (1982) where he stated that "diffusion of innovation is often accompanied by learning about their use in different environments, and that this in turn feeds back to improvements in the original innovation" (Hall 2005:460). The quote reflects upon the way diffusion interacts with the innovative process, which according to Hall has been a less studied field because of difficulties in collecting data. Diffusion and its interaction with the innovation process is however to some extent in focus in this paper which stresses the importance of both internal and external feedback.

Returning to the works of Kline and Rosenberg it becomes clear that they, in line with Schumpeter's view, emphasise the dynamics in the process of innovation. This approach will be taken in this paper as well. The different stages within an innovation process does still cover the identification of a need, research, development, production and diffusion, but the process is not as linear in reality as it appears. Continuous feedback and loops between the stages occur and might improve the initial innovation. The feedback will not however, be possible without communication and a mutual understanding of what is being done in the process of innovation. This chapter will get back to the importance of communication and feedback in a later section. Worth noting at this point however, is that a mutual understanding is not the same as a mutual acceptance. Two actors can share an understanding about an artefact without agreeing on its potential. Furthermore, communication is needed for these differences to be expressed and dealt with.

Innovations and the knowledge society

Having explained what we might understand by innovation, it is time to focus on why it is a necessity. As already mentioned, innovations can be seen as improvements within a society. Innovation is thus "not a new phenomenon" (Fagerberg et al 2005:1). Innovation has occurred ever since the first development of societies. However, during the late 19th and 20th century most parts of the world experienced a development from an industrial society to what Bell (1999) refers to as a "technocratic society". Such societies focus on how something is done and can be done better, making technological development a core factor for economic growth. New techniques are developed due to new knowledge. For some scholars, this has led to the view that the primary factor of production is knowledge, making the usual production factors like land, labour and capital secondary, hence the term "the knowledge society" (Bell 1999, Drucker 1998).

This approach is adopted in this thesis as well as new knowledge is seen as crucial for societal development. Moreover it is important that the knowledge is shared and made available to others allowing feedback from the society to foster further improvements and avoid black-boxing of the technology or knowledge. However, although knowledge is here regarded as the primary factor for production, it is the knowledge and experience embedded in people that count. One might therefore argue that labour, due to the knowledge base possessed by people, should still be included.

According to Bell, the technocratic society represents a new societal structure where networks are key elements. He is supported by the sociologist Manuel Castells who, among other features of the network society, states that new technology has caused expanded possibilities for interaction, creation of networks and exchange of knowledge between people and organizations (Castells 1996). This increases the speed, scale and scope of what is

produced (Bell 1999). Being able to develop accordingly with rapid changes in the surroundings therefore becomes a necessity. All societies, from countries and regions to sectors and organizations, thus depend on innovativeness in order to develop and survive. A foresight report made by the Economist Intelligence unit, states that:

> "Innovation has become the defining challenge for business everywhere. (…) Today, few firms anywhere can feel secure behind their established brands, longstanding customer relationships, proprietary technology, or tariff barriers. The competitive pressure on them is global and immediate."
>
> (The Economist Intelligence Unit 2007, 3rd edition, p. 6)

As pointed out by Pavitt (2005) the artefacts that are developed are increasing in complexity, making the processes of innovation more difficult. In turn, inertia can emerge and make a person, organization or society reluctant towards the unfamiliar. Furthermore, replacing existing technology is costly for a society or an organization because of time and resources needed for change. The phenomena where a society or organization experience inertia towards innovations is often referred to as "lock-in" (Fagerberg et. al 2005).

Different rates of abilities to absorb and change a way of behaving due to innovations, is normally termed "absorptive capacity", meaning "the capacity for absorbing outside knowledge" (Cohen and Levinthal 1990, Fagerberg et. al 2005:11). The term is mainly used in regards to organizations, but can also apply to other societies and even persons as they too have their own old, embedded routines and culture which might serve as a hindrance for new

knowledge or innovations. Differences in absorptive capacity hinder information exchange in communication processes (Powell and Grodal 2005).

Collaboration and innovation

Knowing that research investments rarely lead directly to innovations, moreover that the time from the point at which an investment is made until it pays off can be quite long makes the investment of time, effort and money in innovations costly and risky (Rosenberg 1972, Rogers 2003). At the same time it is appreciated, especially by organizations that face increased competition in their daily operations, that being innovative is a supposition for surviving in the long run (EIU 2007). To share costs, risks and time spent on investing in research, different firms and organizations create alliances (Tidd et. al 2005, Mowery 1988).

According to the foresights of "The Economist Intelligence Unit" the pressure on being innovative is increasing. The number of collaborations are thus likely to increase as well as "collaboration among functional groups and organisations will help companies become more productive and innovative" (The Economist Intelligence Unit 2007:3).

In "Managing innovations" (2005) Tidd et. al presents other reasons in addition to the reduction of time, risks and costs for why firms and organizations collaborate. The achievement of scale economies in production and the promotion of shared learning are also stressed. By the exchange of knowledge and experience, organizations can benefit by learning from each other and gain an understanding of things outside their own knowledge base. The shared learning might make it easier to adapt and absorb the new, although the capacity of absorbing vary in different cases (Cohen and Levinthal 1990). Moreover it is determined by the organizational structure and culture (Tidd et. al 2005). The matter of different motivations for taking part in the alliance as well as different degrees of sharing is also pointed out by

Tidd et. al. Their study did however find no empirical evidence that firms do not “share their knowledge with their peers and competitors” (Tidd et. al 2005:340).

Different types of collaboration

Collaborations can take form in different ways. “The precise form of collaboration will be determined by the motives and preferences of the partners, but their choice will be constrained by the nature of the technologies and markets, specifically the degree of complexity and tacitness” (Tidd et al 2005:340). The different types of collaborations described by Tidd et. al (2005) are subcontracts, licenses, consortia, strategic alliances, joint ventures and innovation networks. The different types differ in duration and advantages and one can divide them into vertical and horizontal collaborations or alliances (Tidd et. al 2005). Whereas the main objective for vertical relations is cost reduction, the motive for horizontal relations concerns knowledge exchange (ibid.). Horizontal relations are normally more long term than those of vertical art (ibid.).

Subcontracting is the typical example of a vertical relation as it is a way of establishing supplier relations and outsourcing non-core activities (Tidd et. al 2005). Licensing is however an example of a horizontal relation as it is an alliance based on paying for the opportunity to exploit another firm’s intellectual property rights (ibid.). Strategic alliances and joint ventures are also horizontal relations and the objective is normally to develop a new technology or product. Such alliances are also a formal agreement such as research consortia, but consortia are more focused on basic research issues (Tidd et. al 2005). In the case of the LowHeat consortium, the main objective is to perform research and develop a new technology for recycling of waste water. The commercialization of the results and the development of a potential product happen after the project's formal period is over.

The final type of collaboration is the innovation network. The literature varies when defining what innovation networks are, but in general terms they are networks of representatives from organizations who meet both formally and informally and exchange knowledge and experience. The relation is thus horizontal and long term.

Consortia

Consortia, the type of collaboration studied in this paper, has a medium term of duration. EU framework funded consortia have a fixed period of two or three years depending of the project. The main advantages of consortia according to Tidd et. al, is the expertise held by the different participants, standards and share funding. The disadvantages are "knowledge leakage and subsequent differentiation" as consortia are "horizontal relationships (…) between potential competitors of sources of complementary technological or market know-how" (Tidd et al 2005:292).

In the case of research consortia, "the rationale for joining includes sharing the cost and risk of research, pooling scarce expertise and equipment, performing pre-competitive research and setting of standards" (Tidd et. al 2005:299). The consortia, defined in the article as "multi-firm collaborations", might take form as either a "collaboration between competitors or non-competing firms" and is "particular attractive when supported by government or EU funds" (Tidd et. al 2005:302). "Firms commonly collaborate with competitors in the development of pre-competitive technologies" (ibid). This is the case for LowHeat as well.

3.2 Social constructivism and the actor-network theory

As mentioned in the chapter overview, this study of internal determinants for diffusion includes the interaction between human and some non-human actors in an innovation process. The focus on the actors' influence on the process of innovation derives from the school of social constructivism where "The Social Construction of Technological Systems. New Directions in Sociology and History of Technology" by Bijker et al (1987) is a main contribution. The core in social constructivism is that science and technology are shaped by social processes as opposed to technological determinism which focus on the way social actors are determined by technology. The case study of LowHeat explores the matter of how a technology's destiny might be affected by social processes.

The actor-network theory (ANT) does however not focus on only social actors' participation of developing new technology (Pinch and Bijker 1987). As previously mentioned, ANT includes all actors that have an effect on the creation of science and focus on the relations between both human and non-human things and concepts.

The ANT was developed mainly by Bruno Latour, Michel Callon and John Law as a contribution to "sociology of science", meaning studies on how and why science is performed. The authors wanted to respond to the way the forces of non-human actors had been ignored in literature regarding the creation of science. Moreover, ANT came as a criticism towards the way science is black-boxed; closed and appreciated as established facts. ANT suggests an opening of these black boxes by going back to the process of innovation and studying the actors that were involved in the creation of science. Although performed in a limited sense, this is what this study attempts to do with LowHeat.

By going back in the process of innovation, this study investigates how non-human actors as time, motivation and language have interacted with the partners and affected their

creation of understanding. As ANT also points out, although such "networks can facilitate innovation, they can also constrain it by determining the kind of innovations produced, their subsequent interpretation and their final use" (Callon 2002, Powell and Grodal 2005:74). Thus, the networks of human and non-human actors in an innovation process might limit the range of possibilities of an invention by determining its fate prior to its development. The research consortia funded by EU are in danger of doing so as they have to follow strict guidelines when applying for funds and state exactly what they will develop, how they will do it and what the result will be. They might in other words be "locked-in" by their initial motives and become inert and unreceptive to changes during the project.

Although indicated by its name, ANT is not a theory about networks, which has given cause for criticism. Among some scholars and students studying the sociology of science, describing ANT as a tool is more common. The main authors behind ANT themselves state that it is not a theory (Hassard and Law 1999). They do not appreciate critics who claim ANT fails to offer a satisfactory theory of the actor and states that the fact that it is not a theory is what actually makes it so easy to use (Callon 1999). This might support the notion of describing ANT as a tool.

For the purpose in this paper, ANT is used in a limited sense as a tool to include the influence of non-human actors, or internal determinants, like time, motivation and language. It is therefore not an attempt to use ANT to explain interpersonal relations among the members of LowHeat. ANT is included in this study to illustrate how some non-human actors affect their communication. The field of social constructivism and ANT is however much broader and elaborative than presented and used in this context.

3.3 Communication and organizational theory

The research consortium covering the members of LowHeat can and will be analyzed as an organization. Organizations are defined by Edquist (2005:182) as “formal structures that are consciously created and have an explicit purpose”. “Organizational participants are those individuals who, in return for a variety of inducements, make contributions to the organization (Scott 2003:21)”. In the case of LowHeat, the organizational participants are the members of the consortium representing a selection of SME’s, Industrial Association Groups and research performers from a total of six nationalities. Such a variety of members might according to some scholars enhance the process of innovation. “Innovations often depend on people operating together having differences, exchanging opinions, expressing criticisms, different perceptions of reality and different backgrounds” (translation from Brandi et. al 2004:31-2). These differences can cause creative dynamics and tension which can be exploited for innovation purposes (Brandi et. al 2004).

Scott (2003) presents a collection of different theories on the subject of organizational innovation, dividing different perspectives on organizations into rational, natural and open systems. When studying organizations as rational systems, the organization is regarded as a “highly formalized collectivises oriented to pursue specific goals” (Scott 2003:30). The natural system approach however, “views organizations as social systems forged by consensus or conflict, seeking to survive” (ibid.). The third perspective of studying organizations according to Scott, is using the open system approach in which organizations are regarded as “activities involving coalitions of participants with varying interests embedded in wider environments” (ibid.).

In line with Scott’s perspectives on organizations, Edquist’s definition of organizations would fit well under the rational approach as it emphasises the explicit purpose

of the group. However, it is not a matter of course that all participants in an organization, like a consortium, share one goal or agree on the purpose of the organization. The participants might have "multiple loyalties and identities", meaning that "they join and leave in ongoing exchanges (…) and cannot be assumed to hold common goals or to seek the survival of the organization (Scott 2003:29). The open system approach therefore seems more applicable in this study in order to emphasise the potential varying interests held by the consortium members.

Another way of regarding the consortium is like a micro level "system of innovation". Edquist describes systems of innovations as "all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations" (Edquist 2005:182). Moreover, Edquist writes that "the main function of a system of innovation is to pursue innovation processes, i.e to develop, diffuse and use innovations" (ibid.). This correlates with the already presented objectives of research consortia. However, because of the emphasis put on communication theory and interactivity in this thesis, the consortium will be studied as an organizational team instead of a system of innovation as the literature concerning communication in group processes mostly studies groups as organizations.

Strong and weak ties

Innovation networks can be seen as an "organizational response to the complexity of uncertainty of technology and markets" (Tidd et. al 2005:308). In studies of such networks, a division between strong and weak ties is often made because of the effect the ties have on the information being exchanged (see Powell and Grodal 2005). The same division can be made within research consortia.

The matter of ties was firstly introduced by Granovetter's (1973) article "The strength of weak ties". "In interpersonal terms, a strong tie is a person with whom one interacts on a regular basis, while a weak tie is an acquaintance or a friend of a friend" (Powell and Grodal 2005:61). While "strong ties are important for social support", the weak ties are the ones offering novel information (ibid.). Furthermore, the weaker ties are easier to cut than the strong ones.

As with friendship, ties become stronger as relationships develop and trust is established. "When relationships are deepened, greater commitment and more thorough knowledge sharing ensue" (Powell and Grodal 2005:60). Moreover, trust has been observed to increase "resource-exchange and combination between the business units that contributed to product innovations" (Powell and Grodal 2005:72, Tsai and Ghoshal 1998). Ties of trust should therefore be established in order to obtain the best possible exchange of knowledge within a consortium. This is because "open and efficient communication presupposes a certain degree of trust" (Translated from Grenness 2002:132). Without communication no exchange of knowledge or experiences can take place.

Tacit knowledge

Trust and strong ties have also been proven necessary in the sharing of tacit knowledge (Asheim and Gertler 2005). Tacit knowledge is knowledge embedded in an individual, a routine, an organization or a process. It is valuable knowledge that is possessed but not easy to communicate verbally. This type of knowledge is however essential in alliances with the objective of sharing knowledge and collaborate on innovations.

Although it is more difficult, the transfer of tacit knowledge is extremely important as it cannot be learned by reading, but needs to be experienced and shared over time. This is why

trust and face-to-face communication is essential in the transfer of tacit knowledge and also why a long term relation is more suitable for transferring it. “Complex tacit knowledge can become more explicit as partners develop a wider bandwidth of communication” (Powell and Grodal 2005:75).

Face-to-face communication

Only through face-to-face contact can relations of trust, causing efficient exchange of knowledge, be well enough developed (Gallié and Guichard 2005, Hildrum 2007). However, “Rallet and Torre (2000) show that efficient innovative collaboration does not necessarily require permanent co-location if an establishment of trust and efficient communication routines has been developed between the project members prior to the project” (Hildrum 2007: 470). This is however not the case for all participants of the LowHeat consortium studied in this paper.

In the article “When is frequent face-to-face interaction necessary in innovation?” Hildrum (2007) presents the ongoing debate about the role of face-to-face interaction in innovation projects. The article seeks to explain why some innovation project groups manage to collaborate efficiently with few face-to-face interactions, whereas others do not. Hildrum writes that

> “Due to increasing complexity of innovation processes, as well as the international dispersion of the knowledge inputs that are necessary in such processes, firms find it more frequently necessary to undertake their innovative activities by way of time-limited collaborations with firms that are situated outside the local environment” (Hildrum 2007:467).

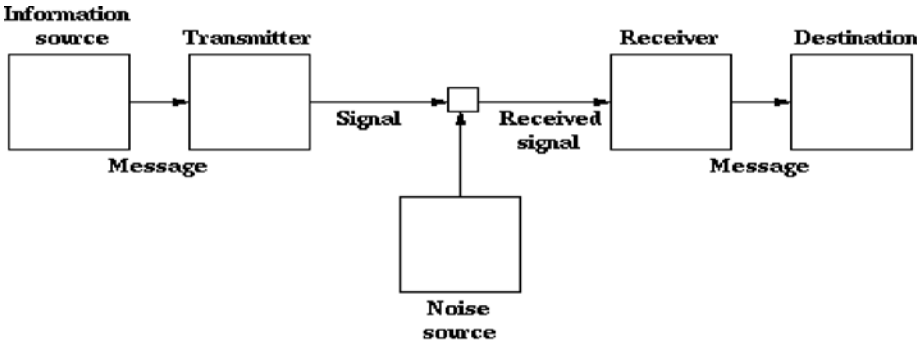
As pointed out by Hildrum (2007) who sites Allen (1986) and Salter and Gann (2003), it is difficult to succeed in such collaborations because of limited possibilities for face-to-face interaction. Some authors view face-to-face interactions as a precondition for successful innovation collaborations (see Asheim and Gertler 2005). Hildrum's research (2007) however, shows contradicting results in this respect as one of the cases studied in the article turned out successful even with little face-to-face interaction. Instead phone, email and video conferences were used. In this case, relations of trust were established prior to the project, in line with Rallet and Torre's view (2000) and supporting Olson and Olson's (2003) argument that videoconferences "are still inadequate as means of developing trust" (Hildrum 2007:480). One can argue however, that video conferences represent a certain element of face-to-face communication.

Communication model

To illustrate the influence of non-human actors in communication, the often cited communication model developed by Shannon and Weaver (1949) might prove useful. Most communication models today are based upon the Shannon and Weaver model. However, even though the model is still cited after almost 60 years, it has been criticised for being linear and not including feedback (see Chandler 1994). Nor does the model include the element of time. Its wide use probably stems from it being simple while at the same time illustrating key elements in communication. That is at least the motive for applying the Shannon-Weaver model to this study.

The model suggests that all communication consists of an information source, an encoder, a message, a channel, a decoder and a receiver (see figure 1). The key in the model is the way the element of noise is included as interfering factors in the process of

communication. Loud sounds are noise in the literal sense, but concerns, difficulties of understanding each other, lack of interest and motivation and stress are matters which too can create noise within the receiver, thus affecting the process of decoding the message.



Shannons "Schematic diagram of a general communication system"

Figure 1

Acknowledging the element of noise and different factors that can cause noise interfering with the process of communication is an important feature of leaders who appreciate the importance of good communication (Grenness 2002). “This can be obtained by valuing creative communication in which noise is transformed to relevant information” (Translated from Grenness 2002:25, Wilden 1972). The role of leadership should however not be seen as the only solution to avoid noise. In addition it might the way a group is organized and put together and that their objectives premises for taking part are mutual.

The creation of a mutual understanding

“Communication is a process in which participants create and share information with one another in order to reach a mutual understanding” (Rogers 2003:5). This definition is much narrower than the one earlier presented by Grenness (2002). However, it underlines the way

creation of a mutual understanding about a matter can be regarded as the purpose of communication. Having somewhat the same understanding of what is being communicated makes the exchange of new information and knowledge easier. Thus, efficient communication is a necessity both for creating a mutual understanding, and for continuing the exchange of information.

Communication theorists have written about the importance of making sure there is a common understanding between different actors in order for new information to be absorbed (Grenness 2002, Svedberg 2002). The importance of understanding is also emphasized in studies of work psychology to show how fear and uncertainty among workers in an organization can be avoided by making sure that the new is understood by all (Arnold 2005). If understanding is lacking, there is a risk of the message not being adopted or that the message will be transformed when spread to others. Moreover, a change of the message can occur due to barriers or obstacles in the communication process.

Rogers (2003:19) writes that "while the transfer of ideas occurs most frequently between two individuals who are similar, participants in the diffusion of innovations are usually quite heterophilous". This applies for the members of the LowHeat consortium as well, as they are partners with different nationalities, background and possibly even different perceptions of reality. The creation of a mutual understanding might thus take longer time because of the heterogeneity of the group.

Leadership and motivation, group processes and feedback

As the section on strong and weak ties suggested, consortium members can have different relations to the project and the other participants. As individuals they might have their own, not always mutual, objectives for taking part in the project which can cause ambivalent

relations between the consortium members. The different strength of ties the partners establish with other partners, the consortium agreement and the innovation itself, can illustrate this ambiguity. If trust is established by face-to-face interaction, the establishment of trust towards an invention might seem impossible. However, understanding the new and seeing how it works can establish a relation which can be used to make decisions about whether to accept the innovation, or not. This will be elaborated in a later section on Rogers (2003) innovation decision model.

The consortium members can thus have divided interests. On one hand they have agreed to take part in an innovation process with an established goal without anything formally holding the members to the project after the funded period is over. The tie to the consortium agreement can therefore be either weak or strong, depending on the members' view of the project and the other partners. On the other hand, the different members might have different motivations for being a part of the project. As the project develops, their motivation might decrease, causing a less active role at some members.

Efficient leadership and management have been seen as a way of motivating members of an organization (Arnold 2005). Motivation is defined as "the factors which determine the effort, direction and persistence of a person's behaviour" (Arnold 2005: 624). One might therefore suggest that a leader should seek to obtain each participant's effort and persistence. However, different people are motivated in different ways, making it difficult for a leader to motivate everyone at once. Moreover, participants might have different reasons for taking part. This is why creating cohesion and a feeling of commitment to a project is important. By doing so, the group is more likely to work as a team. "Efficient teams are characterized by the members making decisions together, accepting each others differences and listening to each other" (Translated from Svedberg 2002:210-11). Furthermore, "a clear and defined goal

understood by all, necessary competence available, the group's ability to be self-critical, low struggle for power in addition to efficient communication, are crucial factors" (ibid).

Literature on organizational behaviour and communication stresses that a leader should be aware of and open to signs of decreased motivation (see Arnold 2005). This can be one of the reasons why efficient leadership and the skills of communicative competence are "concurrent with the ability to precede organizational innovation" (translated from Grenness 2002:110). In line with this statement, Anderson and King (1993) describes a particular style of leadership as critical for innovation in which openness, personal initiative, feedback, demonstration of trust and appreciation of human resources and tacit knowledge are mentioned as core features (translated from Grenness 2002:110).

3.4 Diffusion of innovations

The core of this paper is to see internal collaboration processes in relation to diffusion. So far this chapter has presented theories on innovation, why firms collaborate, the necessity of relational trust to achieve efficient communication and mutual understanding and transfer of tacit knowledge and the importance of face-to-face communication in collaborations where trust is not established prior to the project. In the following it is thus time to present theories on diffusion.

Diffusion

Diffusion is in this context understood by the process in which an invention is turned into an innovation. This happens by the invention being adopted and used (Fagerberg et. al 2005).

The innovation process does therefore include both the invention as well as the adoption of it, and diffusion is a part of the process of innovation.

Studying diffusion of innovations has been and still is of high interest and importance. Spreading knowledge and making it available to others is what causes revenue on the investments put in the research, while at the same time allowing feedbacks and improvements of the invention. This is why diffusion is more than making innovations "useful by being spread throughout a population" (Hall 2005:460). Diffusion is also an "intrinsic part of the innovation process, as learning, imitation and feedback effects which arise during the spread of a new technology enhance the original innovation" (Ibid., Kline and Rosenberg 1986). This evolution occurs over time.

Diffusion and communication: a close link

The view of diffusion as a process over time has been stressed by one of the renowned authors on the topic of diffusion, Everett M. Rogers. In 1962 Rogers published "Diffusion of innovations", a book which is now (2007) out in its 5th edition.

In the preface to the latest edition, Rogers explains the need for editing because of great changes in communication technology, larger focus on marketing, expanded understanding of diffusion networks, and the use of field experiments to test the effects of opinion leaders (Rogers 2003). All connected to the area of communication, a field which, according to Rogers, fits with his vision of future diffusion research: "(…) more generalized, involving various disciplines, but with a firm grounding in communication theory" (Rogers 2003:xvii). Hence we can infer that diffusion theory is closely related to communication theory. This is also emphasized in Rogers' definition of diffusion presented earlier.

Decision making processes

Rogers regarded the innovation-decision process as "the most important part of the diffusion process" (Luktvasslimo 2007:15):

> "The innovation-decision process is the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to the formation of an attitude toward the innovation, to a decision to adopt or to reject, to implementation and use of the new idea, and to confirmation of this decision".
>
> (Rogers 1995:163)

From these words of Rogers, five main steps in the innovation decision-making process appear: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. One might say that the attitude towards innovation is developed by each decision makers understanding or the innovation. In an ongoing innovation process this attitude might change during the project period.

"The model can be criticized for not encompassing the crucial element of time" (Luktvasslimo 2007: 15).

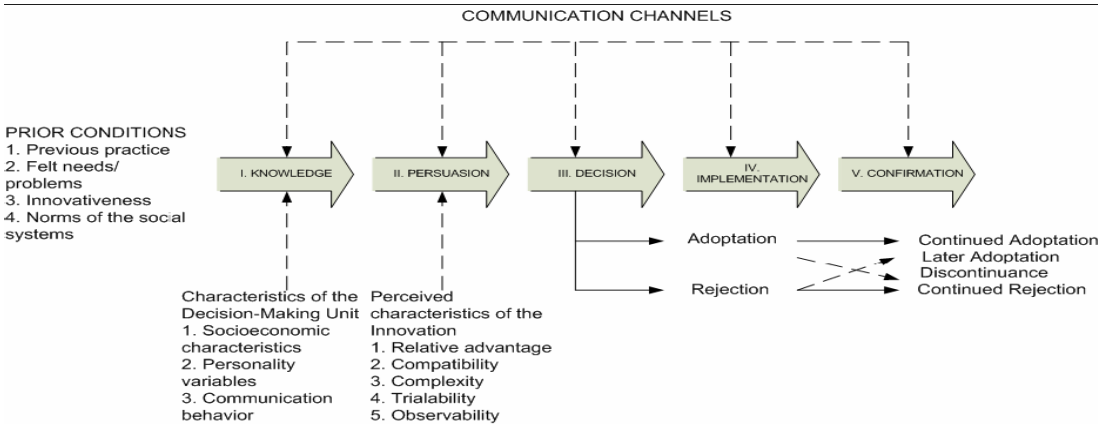


Figure 2: Rogers' Innovation-decision making model

Like potential adopters, consortium members too have to go through a phase of innovation-decision making. The model might thus be used for internal purposes as well, regarding innovation processes. In the case of LowHeat, the members might have gained knowledge about what they were trying to invent before developing an attitude toward the innovation as the project developed. Furthermore, the members went through a phase of deciding to adopt or reject the idea, before implementing it. One of the differences though, between the actual members of the innovation process and the potential adapters of the invention, is that while the decision-making process is more likely to be causal for the potential final adapters, the process is dynamic for the consortium members as they are part of developing the innovation.

Understanding and communicating knowledge

As the section on diffusion of innovation has shown so far, words like learning, experience, understanding and interaction are mentioned repeatedly in regards to studying diffusion processes, with communication as the common denominator. This might have to do with the fact that the best way of perceiving diffusion of knowledge is by making others not only aware that the knowledge exists, but also able to understand the impact this new knowledge will have and to understand how this knowledge will be of help and use. And as literature has demonstrated, this is done by communication and interaction between different actors. In cases where there are several actors involved in the innovation process, creating a common understanding is thus very necessary to breed efficient feedbacks and loops in the process of making. However, one can not avoid the fact that successful diffusion depends upon the invention as well.

Although a research consortium is a small group, the obstacles they face in understanding the innovation, the concerns they might have or the way they establish a

connection to the artefact, are likely to be the same as out in society. As the consortium members represent their own interests while at the same time work together, the consortium might be strengthened because group thinking[7] is avoided and real-life challenges are more likely to be discussed already in the process of inventing. This does however presuppose that the consortium members are exposed to the final prototype of the invention. As the empirical chapter will present, the LowHeat consortium experienced difficulties in seeing the same potential of LowHeat because they were not to the same extent exposed to the invention.

3.5 Summary of theoretical framework

This chapter has presented theories of innovation, communication and diffusion. It has also given a brief introduction to studies within sociology of science and Actor Network Theory. The objective in the empirical part will be to use this theory to see how certain non-human actors affect the consortium members' understanding of LowHeat and their thoughts about continuing the project and take part in the process of diffusion.

As presented in the section about collective research, it is a goal for the consortium to produce, develop and diffuse an invention. However, the aspect of the consortium promoting shared learning must not be forgotten (Tidd et al 2005). Moreover, the consortium establishes ties of different strength with other consortium members which in turn can lead to new collaborations and foster new innovations. As presented by literature, these new collaborations might benefit from trust already being established prior to the project.

[7] Psychologists refer to "Group thinking" when describing a mode where a group is so bound together that their ability to reflect critically over the groups' actions is weakened. Examples from the military are often used.

Powell et.al (1999) found that experience in collaboration attracts new alliances and causes a widening of organizations' networks which makes the organization more visible in the industry. Furthermore, "external linkages facilitate innovation, and at the same time innovative outputs attract further collaborative ties. Both factors stimulate organizational growth, and appear to enhance further innovation" (Powell and Grodal 2005:67-8). Consortia that do not continue development of their research should therefore not be considered as flaws. The benefits from taking part in a research consortium might bear fruits at a later stage. The argument in this thesis is however that diffusion of consortia's results should be pursued whenever the results meet the project's objective.

As illustrated by the works of Hildrum (2007) and Tidd et. al (2005), studying the communication processes in collaboration projects is not new. However, given the presented theoretical framework, it seems interesting to study the communication and interaction within a consortium's innovation process in relation to the matter of diffusion. As the reviewed literature on diffusion has stressed, the focus often lies on which factors outside the innovation makers decide the diffusion process. This paper argues however, that because of the increasing number of collaboration projects, a study on factors inside the process of innovation can prove useful. The study is limited in regarding only one type of collaboration, namely a consortium. However, a consortium can, as this framework has presented, be regarded as both an organization and a micro scale system of innovation, meaning that some of the findings might be useful for other types of collaboration in innovation projects to come by shedding light on the impacts of internal determinants.

Chapter 4: Methods

This chapter aims at presenting the methods used to investigate and collect data in order to answer the presented research questions. The approach taken in this thesis is a case study and the case is what has given inspiration to the research questions in this thesis. This was implied already in chapter two, which presented a brief introduction of the LowHeat consortium. The present chapter will elaborate on why the case study approach has been chosen to explore the interaction and the degrees of understanding among the consortium members and in what way this might affect the diffusion of the consortium's research results. Furthermore the methods, as well as how and why they were used to study the case, will be described. These methods consist of questionnaires, informal conversations and observations, all performed at the same time. Documents regarding LowHeat were read before commencing the case study in order to have some knowledge about the technology with which the consortium is dealing.

The findings from this paper thus derive from qualitative methods. Moreover, the point of departure is exploratory, in the way this study focuses on current events and concerns and seeks to answer questions of *how*. Moreover it "seeks to find out what is happening, to seek new insights, to ask questions, and to assess phenomena in a new light" (Winegardner 1999:6).

4.1 The Case study approach

According to Yin (2003), the aim of a case study is to describe a complex social phenomenon in its context. This refers to the way it uses "in-depth studies of geographical areas, institutions, persons or processes as its point of departure" (translated from Østbye et. al 2002:244). For this paper it is the process of innovation that is studied in the context of a

consortium. However, the emphasis is placed on the processes of communication and interaction taking place within the consortium as well, because the communication can be seen as the foundation for the innovation process to take place. This study does not deny that there are other processes also taking place within the innovation process, for instance the process of developing the technology or the process of planning the work of the consortia. However, as it is the objective to be able to say something about how some degree of understanding is reached among the consortium members and how this might affect the diffusion of their invention, this study will focus on the process of interaction and communication within the LowHeat consortium.

The words of Winegardner explain why the case study approach is suitable for this matter. According to her, "by concentrating on a single phenomenon or entity, the researcher aims to uncover the interaction of significant factors characteristic of the phenomenon" (Winegardner 1999:4). In the study of LowHeat, the aim is to uncover the factors involved in the consortium's interaction from which the members' understanding stems. If there is no mutual understanding of the artefact, chances are that the members will not participate as actively in the discussions, or that there will be no discussions at all. As the theoretical framework presented, the dynamics of innovation processes presupposes feedback. Furthermore, it is how each member understands the artefact that decides whether or not he or she believes in it and would want to invest resources in developing it further.

"The case study approach focuses on a holistic description and explanation" and "as a general statement any phenomenon can be studied by case study methods" (Winegardner 1999:4). However, in contrast to quantitative studies, qualitative studies like the case study approach presuppose that no generalization can be done. A case study works well to describe and explain a certain phenomena within a given context, but a researcher can never draw conclusions from one case to another. The results of case study are therefore valid only for the

exact case, at the exact time of study, in the exact context. The results can however be used to create hypotheses or new theories that can be tested in studies to come.

"Yin favours exploratory case studies, such as the one performed in this paper, only when the available literature or existing knowledge base is poor" (Winegardner 1999:6). As shown in the theoretical framework, there is a lot of literature regarding both collaborations in innovation projects and diffusion of innovations. In regard to how these matters relate to one another, how the process of collaboration can have an effect on the diffusion, there is less literature to be found. In cases of EU framework funded research projects there is a natural link between the collaboration and the diffusion. This is because diffusion to a great extent depends upon the continuance of the collaboration or that the consortium gives the intellectual property rights to others. It is however, less self evident how the interaction affects the members' degree of understanding the artefact and how this in turn can affect the diffusion. A case study approach has proved useful when attempting to explore that matter in this thesis.

4.2 Questionnaire

The LowHeat consortium has been observed and studied in both formal and informal settings, the members have filled out questionnaires and some of them also took part in informal chats. The collection of data is based upon a combination of these methods, but the emphasis has been put on the questionnaire which is presented in the Appendix. Questionnaires are a good method for collecting data as they allow the researcher to collect a lot of information by using less time than with interviews. It was important to get feedback from as many consortium members as possible, and as they only meet once every third month, there would not be enough time to interview all members during that five hour meeting. This was the main argument for using a survey as the main method of investigation in this study.

The questionnaires was divided into four sections regarding general information, the member's relation to LowHeat, the communication and interactivity in the innovation process and finally the understanding of the artefact. The overall objective for the questionnaire was to get the members' own impressions of the interaction, which prospective challenges they have faced in communication with other members during the project and what their current understanding of LowHeat is. By getting insight in how the members understand LowHeat, the questionnaire at the same time sought to give answers to their attitudes towards further development of the artefact and an impression of how and if the members are likely to take part in diffusion of the research results. The questionnaire also contained questions regarding the members' motivation for taking part in LowHeat.

In order to get elaborative answers and impressions, the questionnaire consisted of mostly open, qualitative questions giving each respondent the opportunity to speak freely and express as much as possible on every question. In addition, the survey had quantitative questions as well, allowing the respondents to circle the options they agreed to. Having open questions is very useful to get elaborative answers, but since some respondents had English as their second or third language it seemed necessary to have alternatives as well in order to get the most out of each respondent and to save the respondents' time.

The questionnaire was handed out at a consortium meeting held in May 2007 in PERA innovation park in Melton Mowbray, England. 9 of the 12 partners were represented at the time of study, some of them with more than one representative. The number of participants in the study in general therefore amounts to 13. However, one of these was an interpreter for the two Polish partners and one Norwegian partner from the Technology Institute chose not to

submit the questionnaire due to close relation to the research[8]. He did however take part in the informal conversations and observations. The number of surveys analyzed is therefore 11.

The respondents are all men with an age range from 24 to 58. Due to the small group of participants, their anonymity could not be assured. Each participant was however given the opportunity of anonymity in the paper. Only one respondent chose this option. Because the researcher knew who had answered what and was able to observe who did and said what as well, the combination of elaborative questionnaires and observations proved very useful as it became possible to link personal responses with public behaviour.

4.3 Observations and informal conversations: Participating observation

Using observation as a method for collecting data can be done in different ways. One can observe without taking part in the process, either by being invisible to the objects one is studying or by being visible but told to be ignored. After a certain amount of time the study objects are likely to forget that they are being observed and will act as they normally do, giving good and reliable data. Only two days were devoted to the study of the LowHeat consortium. The first day was an informal dinner whereas the formal meeting took place the next day. To avoid a risk of the members acting differently than they normally would do, participating observation was chosen as the method of use.

Participating observation allows the researcher to get close to the study objects. The possibility of the objects performing differently will be present here too, but this risk will be

[8] This participant, Øystein Luktvasslimo from the Technology Institute in Norway, provided feedback in the process of making the questionnaires. The Technology Institute did also fund the travel expenses for the study to take place without interfering in the study itself. Mr Luktvasslimo has however contributed to the study both through providing documents on LowHeat and also through informal conversations.

reduced due to the relations established by the researcher and the study objects. The researcher was therefore not only presented as a student working on her master thesis, but also as a colleague from Teknologisk Institutt AS.

The consortium has a tradition of meeting for dinner and drinks the evening before the meeting to catch up on personal matters, such as family, business and every-day issues. This informal meeting was a good opportunity to learn about the consortium members, the way they communicate with one another and to see what type of information about themselves they shared. By observing this, it was possible to get an impression on the degree of trust among the members. It was also an observation in it self to notice who took part in the informal meeting.

In the consortium meeting the members were observed in a formal setting. This observation was important to see who the most active participants were and how the communication regarding the actual process of innovation took place. Moreover, these observations gave room for studies of where there are faults in the communication as well as an impression of how the different members understand LowHeat. These observations combined with the answers from the questionnaires proved very valuable, as the respondents were asked to elaborate on their relations to the non-human actors language, time and motivation.

4.4 Limitations

With every use of qualitative research methods there are limitations regarding the element of subjective interpretations. Most vulnerable to such interpretations are the findings from the participating observations. Having questions with alternatives makes the questionnaires more

objective. Many of the questions were however open and there is always a possibility of the respondents interpreting the questions differently. However, due to the informal way the survey took place, and the low number of respondents, the members were able to ask questions if there was some unclearness. As already mentioned, there is also the element of language present in the way that only the English and Norwegian speaking respondents were able to answer in their mother tongue.

Not only are the methods used, but also certain words in the research questions studied in this paper, open for subjective interpretations. Measuring interaction and degrees of understanding is done by observations and the members' own impression of it. One can also question the definitions of interactivity and degree of understanding. In this study interactivity has been measured qualitatively by observations and open questions giving answers to how the communication is taking place. In addition, the interactivity has been measured quantitatively in the survey asking the respondents to state their communication frequency with the other members.

The degree of understanding is measured by the questionnaires asking for each respondent's description and opinion of LowHeat, in addition to the observations giving an impression as to what extent a mutual understanding exists. As defined earlier in the theoretical framework, understanding is in this paper defined as a mode where one has the feeling of adequate knowledge about something and is able to see the meaning behind it, develop an opinion about it and able to communicate this further. The respondents were presented the same definition when asked to answer questions in the section "Understanding the Artefact"[9].

[9] See Appendix 1.

4.5 Reliability and validity

Studying interaction would be difficult without observations. This method was therefore used despite its room for subjective interpretations. Although participating observation was used which created a tie between the researcher and the study objects, these ties was too weak to interfere with the research. One always has to be careful when taking the role as a participating observer, and also in this setting it was difficult to be critical towards people with whom one has had personal conversation. It was however possible to distinguish between oneself as a researcher and as a private person in this study, thus there were no conflicts regarding the role. Representing Teknologisk Institutt AS (TI) did not cause criticism either, as TI performs as an RTD partner in the project, with no private interest. The researcher's role to its student objects should therefore not diminish the reliability of the study.

The internal validity should also be considered as high due to the way the questionnaire and the observations and chats provide data regarding the interactivity and degree of understanding within a consortium. The external validity, meaning the way this case can provide information regarding matters outside the specific case, should however be considered somewhat lower. As described in the section on case studies, one must be careful not to generalize the findings from a case study. However, the way the interaction, communication and degree of understanding can affect the diffusion of LowHeat might give inspiration to thoughts and theories on how the processes of communication in consortia to come can affect the diffusion of their results. As the conclusion will suggest, some of the findings from the LowHeat consortium might give reasons to believe that internal determinants in framework funded research projects should be paid more attention in future projects, in line with the initial notion upon which this paper is built.

In August 2007, three months after the questionnaire was performed, the LowHeat consortium held their final meeting which marked the formal closure of the project. The meeting was held at PERA Innovation Park this time as well and as part of the agenda the consortium was presented some of the findings from the questionnaire. The general response among the consortium members was that they could relate to the findings. Moreover, their attitudes towards further development were somewhat the same. This supports the reliability of the study.

Observations and informal conversations that took place in August 2007 is a part of the study as well due to the way it affects the researcher's perception regarding answers to the research questions. Moreover, two members that did not attend the meeting in May came to the one in August and it was interesting to observe their understandings as well. The empirical analysis will however not separate between the two meetings, but the findings will be analysed in total.

Chapter 5: Empirical findings

This chapter presents the main results from the empirical analysis and seeks to combine these results with the reviewed literature in order to answer the research questions. In line with the theoretical framework, the empirical analysis will elaborate on collaboration issues such as establishment of trust, interaction and communication. Furthermore it will present how the members' understanding of the artefact, meaning the LowHeat technology, has developed as well as it will include the impact of the non-human actors time, motivation and language. Finally these sections will be viewed in relation to the how these internal determinants might affect the diffusion of the consortium's innovation results.

As described in the methods chapter, not all partners were present at the studied formal meeting held in May 2007. Some of them were unable to come or have taken a less active role in the project as it has developed. The following analysis is therefore based upon 11 questionnaire respondents, informal conversations with several of the attending participants, and observations of all participants and their communication in action. The observations and informal chats took place both in May 2007 and August 2007 covering a total of 14 participants[10].

5.1 Collaboration and communication in the LowHeat consortium

Communication frequency

At the time of study, the consortium has been running for about three years. The members from AK industries and PERA innovation group knew each other prior to the project, but besides that, all members were new to each other. However, after three years in the same project they communicate on a regular basis. Five of the respondents state that they have monthly contact with the other participants, three of them have daily or weekly contact while the remaining three state that they only have contact with the other partners at the meetings. In addition, some partners comment that they have more contact with PERA than the others, which is natural because of PERA's administrative role. All respondents mention e-mail as the most common way of communication. Three members mention phone as well, while the remaining eight state face-to-face meetings as the additional most common way of communicating. All the respondents who use phone are English native speakers which give the impression that the partners are aware of misunderstandings that might occur due to

[10] Some of the organizations were represented with more than one participant.

language barriers, or that non-native English speakers naturally are more unconfident in English speaking settings.

According to the consortium agreement, which has a clear strategy for communication, the partners were to conduct face-to-face project meetings every third month. Although the members are highly encouraged to attend, the meetings are not obligatory. On average the members have met all other partners in person nine times during the project. In the project's application for EU funds the importance of regular face-to-face meetings were stressed due to awareness of its importance for innovation projects.

Face-to-face communication

As the theoretical framework showed, face-to-face communication is essential in the establishment of trust. When asked, all respondents except one answer that they believe the outcome of LowHeat would be different if no face-to-face communication had taken place. Most of these reply that face-to-face communication increases the relations between the members and emphasise how it makes "people tell you things privately which they would not do publicly". Another comment was that "face-to-face communication is crucial as hand and eye movement say a lot. Meeting on a social level is therefore important too". Other statements focused on the way face-to-face communication achieves a better understanding of both the process itself and the other members. In addition, the importance of face-to-face communication was emphasized because "it allows feedback from the people of the consortium".

The one respondent, who believes the outcome of LowHeat would not have been different without face-to-face interaction, does not explain the statement. However, his survey generally expresses a disbelief in the projects results as they are:

> "The main benefits of taking part in a collaborative innovation project such as LowHeat, is the exchange of knowledge and experiences. In addition, it is interesting to see how these EURO projects function. My general impression of the project's outcome so far is that it is an interesting concept, but its potential is questionable. The payback time is too high".

This gives reason to believe that the respondent does in fact see the value in face-to-face communication for relation purposes, just not for LowHeat's success.

The other members in the consortium do also appreciate the value from knowledge exchange in research consortia. All other respondents point out the same; that they are generally interested in taking part in a collaboration project like LowHeat because of expanded networks, diversity of ideas, exchange of knowledge and possibilities for future business. Only the two Polish respondents who are from a Polish industrial association group specify that the main benefits from taking part in the consortium is new technology for plumbing installations. The SMEs thus seem to generally focus on the interest for their own future business, and not necessarily LowHeat itself. Their primary objective is to see whether or not LowHeat has the possibility to cause revenues for their future business. Moreover, they do not want to miss out on the opportunity in case LowHeat becomes a success. These reasons are why their understanding of the artefact at the end of the funded project period might affect the potential diffusion of LowHeat. If none of them decide to develop it further, or if no one buys the intellectual property rights to it, LowHeat as developed by this consortium will be one of many inventions never carried out as innovations.

The degree of trust

The questionnaire and observations supported the theories by Asheim and Gertler (2005) stating the importance of face-to-face communication in innovation processes. By observing and reading their survey answers, it also is clear that face-to-face communication has established a certain degree of trust. However, as pointed out by one respondent "the real test of the collaboration between the partners will be when the funded period of the project is finished".

Having been in the same project for almost three years, the members know each other better and they have gained an interpersonal understanding with whom they best get along. Some respondents even consider each other as friends. Observations from the informal dinner support these relations of trust as the partners seemed to have knowledge about one another and posed follow-up questions. They shared information about their families and work life and discussed everyday and private issues. Four English native speakers, one Spanish and one Norwegian partner attended the informal dinner. The tone was informal and the conversations did not concern LowHeat, but daily life in general. The fact that the partners share personal information appears to be a sign of trust among the present members. It might, to some extent, also be an effect of personal traits in the sense that people open up more easily.

According to some participants it is usually the same people attending the informal meetings. The relations between certain partners might therefore be stronger than others because the repeated informal meetings have made them share personal information and by that established another type of contact than only the formal one. More frequent communication enhances the ties between the partners and establishes trust.

To see the communication in relation to how a mutual understanding has been created, the respondents were asked to explain how they gained better understanding in unclear cases.

All respondents except two asked other partners in the project. One said that he had read to learn more, whereas the other exception was the project manager who has had full knowledge about LowHeat from the beginning. The fact that the rate of members who ask each other is so high supports the impression that there are ties of trust among the members and that the communication has been frequent and well-working. Such matters are likely to have improved the understanding of the artefact among the members of the consortium.

Trust being established among the members has probably been beneficial for transferring knowledge about the LowHeat technology. It is also likely to have influenced the knowledge exchange, and by that the members' understanding of LowHeat. The transfer of tacit knowledge is however difficult to measure and has not been an objective for this study.

Activity in the consortium

The impression that there are ties of trust existing in the group is also supported by observations of partners not afraid to express their meanings or comments regarding the innovation process. In the questionnaire, *all* the respondents stated that they have made comments or suggestions during the process of innovation that has been useful and contributed in further developments of LowHeat. Even though this might be a result of the partners not wanting to undermine their own role in the project, the other alternatives in the survey were more humble and could easily have been chosen instead. The impression of a degree of participation from all consortium members in the process of innovation is therefore given.

Half of the questionnaire respondents characterized their own role as "very active" while two respondents stated that their role has changed as the project has developed. One respondent writes that there was "little involvement in the early parts of the project, but my

participation has increased as more exploitation work has been carried out". In contrast, another respondent states that his role was "more active at the beginning. Nowadays the main role belongs to the associations and SMEs".

The development in the project where the types of partners have different grades of responsibility at different times, can easily impact the communication because the partners might feel there is less necessity of their contribution. This seems to be the case here. While observing the partners in communication, it was noticeable that many of the SME and RTD partners did not say anything unless they were directly asked.

When there is a case of partners taking a less active role at some stages of the process, there might be a danger of important knowledge exchange or feedback not taking place. This can adversely affect the process off innovation if those who develop the artefact and have first hand knowledge about what is being made are not active when planning strategies for diffusion. Those are the ones with best knowledge and understanding about how the artefact works, thus their activity might avoid unnecessary misinterpretations of the artefact throughout the process.

5.2 The understanding of LowHeat

Some differences

In the LowHeat consortium, most partners feel they have the same understanding. This does not mean however, that they really do as the feeling of understanding is subjective. While observing their interaction at the meeting, it became clear that a few of the members still view LowHeat as a solution for domestic use. This was indeed the initial purpose for LowHeat, but after doing tests and figures the idea was revised and the consortium decided they would do

best in working with the industrial market at first. Implementing LowHeat domestically will happen at a later stage if the artefact works as intended.

Both comments during the meeting, and statements in some of the questionnaires show that a couple of the partners still are thinking domestically, which made other consortium members remind the whole group to think industrial market. Although such corrections were made, it still shows that different understandings of LowHeat as a domestic solution exist. If this has been the case throughout the process of innovation, there is a chance that some of the partners have had different understandings of LowHeat throughout the process.

The way some members still think in terms of domestic use might be an effect of the process prior to the project's beginning. When working with the application for funds, the domestic angle was used and all planned activities are related to domestic dwellings and small plumbing companies. Moreover, many of the SMEs are used to work with domestic dwellings and not the industrial market. Thus it is a possibility that the members who still are thinking domestically are more locked in by the initial plan and their regular operation markets and experience inertia towards the new ideas for LowHeat.

Although there are some differences in the understanding of how LowHeat is to be used, only two respondents write that different understandings of the artefact and how it works is a barrier when communicating, giving the impression that most consortium members feel they have understood the artefact correctly.

The partners' relation to LowHeat

Almost all participants say they now fully understand LowHeat and that they would have no problems in explaining the artefact to others. Three respondents do state that there are some parts they do not understand. All of these are active members who in addition see what obstacles LowHeat might meet. This shows how having active members is important go get concerns and feedback out in the process of innovation. One points out that the hot water systems in different EU countries vary, and that this must be better understood, while another does not understand how the waste water will be cleansed in order to extract most heat. So far, LowHeat has only been tested with clean water.

5.3 The impact of non-human actors

Essential in this analysis, is the way non-human actors are given a role in the process of innovation and creation of a common understanding. Abstract matters such as language, time and motivation are studied as they represent issues that do something for, or have an effect on the process of innovation. This has been this paper's way using the actor-network-theory. As explained in the theoretical framework, non-human actors are actors that have an effect on the process of innovation. These actors are numerous and can both have positive and negative effects. For this purpose however, actors like language, time and motivation are paid most attention to as they might have an effect on the communication efficiency. This reference is made to the element of noise in Shannon and Weaver's communication model presented in the theoretical framework. Due to the impact time might have on motivation, these two determinants will be placed in the same section although they have been studied separately.

Language

The questionnaires showed that all respondents feel that the communication within the consortium is well-functioning. Eight of the respondents characterize the communication and interaction as “very good”. However, although writing that the collaboration is adequate, the remaining three respondents all emphasize problems regarding the language differences. The communication coordinator Darren Woodcock from PERA, writes that “the interactivity and communication could be a little better. Language problems are always a little problem”. The other coordinator, representing the main industrial association group IOP, Dale Courtman, agrees, stating that “most partners work well together although the language barriers have at times presented problems”.

Being an important tool for communication, language is crucial in the creation of a mutual understanding. According to the respondents, language differences are the most visible barrier when communicating. When asked what the participants find most difficult in communication with the others, all actors, except two, state language. Many of the respondents state this alternative only, even though they have the option to list as many as they want. It is thus an apparent feature that language differences cause challenges. In the communication strategy for the consortium, this challenge was dealt with by offering the members an interpreter.

The Polish consortium members were most likely to be the ones experiencing greatest difficulties in communication with the others because of poorer English skills. Therefore, the consortium provided the two Polish members an interpreter from PERA who speaks fluent English and Polish, and also has experience in working with research and technology. Because of the interpreter the Polish participants seem to manage quite well. During the meeting there was a session of observing the artefact in action. Because of technical

problems, the session however became different than what was intended and the members did not get to see the finished prototype in action as planned. Still, the Polish partners had questions and suggestions regarding LowHeat. By using body language and the English they knew, they expressed their concerns and were eager to make new suggestions. With the help of the interpreter, they were able to communicate detailed opinions to the other consortium members. The two Polish members explained through the help of the interpreter what the technology was missing, and factors they felt could improve the technology regarding where the pipes for new water was to be installed to save the most energy in the heat tube. In the meeting room after the presentation, the coordinator repeated how he had understood their concerns and how these concerns would be handled.

Although the language differences are dealt with, they do still seem to interfere with the efficiency in the communication process. Having only consortium members who speak the same native language could therefore make the creation on a mutual understanding easier and more efficient. But at the same time, the consortium would risk missing out on important and essential exchange of knowledge due to differences and diversity between the members with different nationalities and background. This could have an adverse effect as diversity is becoming more and more important in processes of innovation (Brandi et. al 2004).

Time and motivation

Time is another barrier repeatedly mentioned by the survey respondents. LowHeat is only a side part of their work and time constraints can affect their engagement and motivation. This is natural because all the members have full-time jobs in addition to their membership of the consortium. Moreover, the meetings take place in different countries forcing the members to travel a lot. Reduced time is a source to stress, and the feeling of the research project causing

stress is likely to interfere with the decision making process regarding LowHeat. Most SME participants are owners and their salary is based upon revenues from their company. As time is a scarce resource for them, it becomes even more important that the communication is efficient. If they do not feel that it is, people might feel stressed. Having limited time does therefore intensify the need for creating a feeling of commitment to the project, which is a task for the leader.

People are motivated in different ways and by different things. By finding out what motivates each individual, the communication can be pointed out in that direction and stimulate the work. In a usual teamwork setting at any workplace, such stimuli and motivation work are performed by the group leader. It is the leader's job to find out what motivates the group and adjust his or her communication according to that to increase efficiency.

In the LowHeat consortium, two leaders have been pointed out; the Project owner from IOP, Dale Courtman, and Darren Woodcock from PERA who is the project manager. Because there is no particular leader, chances are that no one will take on the role of motivating the group as a whole. As this study has shown, much effort put in communication strategies have paid off, resulting in an interactive group where opinions are shared and knowledge exchanged.

However, although ties of trust are created among the members, the ties do not seem strong enough to commit all partners to further developments of LowHeat now that the project's end is approaching. It might seem as if the ties to the artefact is not strong enough, causing a reluctance towards further investments. As the meeting showed, some partners are at the time of study hesitating to invest further. In May 2007 most partners explained their reluctance by not having seen the artefact installed properly and tested under real-life conditions, causing a bit of frustration at the project's coordinator Dale Courtman, who said

“it is a shame that we are not confident enough to put our hands in our pockets after three years of development.”

The reluctance can however also be understood as the partners have not been given the chance to see LowHeat really work. First at the final consortium meeting in August was the prototype was ready, tested and demonstrated. But still most partners hesitated about investing money in further development of LowHeat. They did however agree upon having one more meeting consisting of only SMEs. The hesitation shows that the consortium members do not fully trust LowHeat. Those members already willing to invest more money are those benefiting if the product is commercialised, regardless of its initial success, because they offer parts needed in the technology. The plumbing companies who will be the ones installing and selling the product are however more reluctant, and less motivated. The motivation does therefore seem to correlate negatively with the necessary degree of risk to be taken.

As described in the theoretical framework, motivation decides which effort, direction and persistence the partners and the group as a whole put into the project. Often motivation is linked to what one can achieve from taking part. It therefore becomes clear that if a consortium member does not see any benefits, only risks from collaborating or from the developed artefact, the motivation will decline.

In the survey however, only one respondent listed differences in motivation and that not all actors share the same passion for the project as a barrier in the communication process. Although differences in motivation might not appear to be interfering in the communication process, the observations showed that little motivation for further development of LowHeat indeed affected the way some members spoke about LowHeat. Furthermore, motivation is an

important actor in regards of further development of LowHeat as no one will decide to continue the collaboration unless they are motivated.

5.4 Internal determinants' effect on the partners' understanding

So far this analysis have presented how and to what extent an establishment of trust has been made, how the interaction and communication has been in the consortium and how an understanding has developed with a particular focus on language, time and motivation. The following section, which is the final part of the empirical analysis, seeks to relate the findings from the previous sections to the matter of diffusion.

After three years of development, the consortium is divided as to how they view the goal of the LowHeat project. Whereas three respondents point out that energy savings or avoiding waste of energy is the goal, the remaining eight respondents focus on commercializing a product in a market. These answers correlate highly with how they regard the artefact; as an environmental solution or a potentially commercial product. However, as in line with all the objectives listed in the consortium's work package, in order to create energy savings at macro scale, a product has to be commercialized. Only commercialization will lead to diffusion of LowHeat. Diffusion of the knowledge regarding the technology might take place, but diffusion of LowHeat, applied, direct use of the knowledge, will only happen through commercialization.

The empirical findings show that ties of trust have been established which are about to be put to the test now that the funded period is over and the work with exploiting the results are about to begin. What has been developed so far is not a finished product but a prototype that has to be developed and exploited further by the partners involved in the consortium. The

question thus remains to what extent this exploitation will take place. The ties between the members, what understanding they have of the artefact and how they regard the non-human actors that will be involved in the commercialization are all factors that matter for the diffusion of the consortium's research results. Consortia are therefore interesting cases for studying internal factors that might interfere with the process of diffusion because the end result to a higher extent depends on the interrelations between the members. Such reasons have given reason to focus on trust, communication, commitment and the creation of an understanding in this paper.

Reluctance towards further development

This paper focuses on communication as essential in every innovation process because a mutual understanding of what is being done has to be created and because ties of trust to both other members and the produced artefact have to be established in order to successfully diffuse the invention. An interesting finding is that none of the members are concerned that the technology will not save as much energy as first anticipated. Moreover, only two members believe that people or potential customers will not see the need for an artefact like LowHeat. In general, the consortium members therefore seem to trust the technology. They do however not share the same faith in the commercialization of the technology, as they do in the technology itself. The project's coordinator has probably suspected such a development. His only stated concern regarding the future of LowHeat was "consortium politics".

The reluctance and hesitation towards saying yes to further development of LowHeat can best be explained by the fact that few members have seen the prototype in action, not to mention tested with dirty water.

Non-human actors such as the components involved in LowHeat were not working together as intended, which caused difficulties in making the prototype ready. That the prototype was not shown to all members because of technical difficulties, created disbelief among some partners. First at the final meeting held in August 2007 the prototype proved to the consortium that the LowHeat technology worked. However, even though a filter has been developed to cleanse the water from particles hindering the recovery efficiency, the prototype was only tested with clean water. The disbelief therefore remained even after seeing the prototype. The actors in real-life waste water who should have been involved in the process of innovation have thus not been included, causing a lack of understanding and faith in the prototype. At the same time, the partners have felt and seen the technology work, which might explain why there is a mutual understanding and trust regarding the heat exchanger technology.

The technology is available, a market has been identified and the knowledge to exploit the technology further is present in the group as a whole. Still, there is reluctance among the consortium members. The uncertainty regarding other partner's commitment is also commented in the survey as one respondent writes that the general impression so far *is* "very promising, if partners continue their support". The other respondents mostly use the words "promising" or "ok".

When asked which possible barriers the different members regard as most likely to interfere with the success of LowHeat, most partners describe external factors. All partners except one express a concern that prices, mostly the production costs for LowHeat, will be too high. Half of the respondents are concerned about the differences in houses or buildings, making the instalments difficult. Three respondents, with plumbing engineering background, representing SME's, are worried that particles from waste water will stick to the plumbs and slow down the heat exchange. In addition, one respondent states that competing technologies

might cause barriers. Only the already mentioned project coordinator acknowledges the role of internal determinants, stating consortium politics as a potential barrier.

Energy prices as an actor has been involved in the calculations of how LowHeat can save money. But price, either it is the cost of production of energy, is not a stabile actor. If the production costs increase, the product might be too expensive. If energy prices decrease, the savings will not be as much as accounted for. Either way, LowHeat will still be a matter of saving energy, which is environmentally beneficial for societies as a whole. People's attitudes towards energy saving products vary however. So does the differences in pipes and plumbs between countries in Europe.

Strong or weak ties

Ties can be created not only between humans, but also between humans and artefacts. As the study shows, those who are most sceptic towards the final product are the ones working with plumbing installations and not the RTD performers who have directly developed LowHeat. It could be that their ties thus are stronger to LowHeat. Another example is AKI, who have developed a lot of the heat exchange technology that LowHeat consist of. These representatives have strong ties to LowHeat and express eagerness in continuing the development while those who will be the ones bearing most of the costs if the product fails in the market, are naturally more concerned. Such concerns also affect the motivation.

The members do not seem to think as a community working for their mutual benefits which might reflect a lack of organizational or societal behaviour. The way some members make a distinction between their relation to the other partners in the consortium and the project's goal can serve as an example.

The consortium's "description of work" presents well-planned strategies for exploitation and dissemination activities. However, as presented in the previous section, all these plans might fail if there are no partners motivated enough to carry them out. When writing the work package or application for the EU funds, a high focus on communication strategies were also described, showing the importance of creating a well functioning communication among the members. However, it might seem as the matter of motivating and creating a feeling of commitment to the group and the artefact has been underestimated. Having one, clear leader focusing on motivating all actors from the very beginning and presenting a clear and defined goal could have made the ties stronger between all partners and LowHeat. The project manager Darren Woodcock reflects upon the latter himself in his questionnaire response: "The project has gone ok. The project scope at the beginning was wide and should have been more defined as the project started".

5.5 Summary of the empirical findings

The overall impression as presented in this empirical chapter is that the communication is good and well-functioning and that ties of trust between the members have been established. A mutual understanding is to some extent created, although there are differences in whether LowHeat is regarded as a potential domestic or industrial product. The understanding of the artefact also differs when it comes to how LowHeat's further potential is regarded, showing that the ties to the artefact vary among the members. A greater focus on creating an organizational behaviour within the consortium, making the members think on behalf of the group could have enhanced the feeling of commitment. Furthermore, the members could have been motivated by a continuous focus on how each and everyone might benefit if the artefact is diffused. It cannot however, be proven with one single case study. Moreover, it is important

to stress that commitment is difficult to measure. In this case study, commitment is analysed out of each respondent's given impression of his tie to the project and the artefact.

The partners' different reasons for participating in the project prior to its beginning are what set the level of commitment. Thus leadership and motivating strategies could end up having little or no effect. As the analysis has shown, the exchange of knowledge and experience is highly appreciated among the members and is their main motivation for joining the project. In that sense the matter on whether LowHeat is commercialized and diffused or not does not seem to mean as much as the links and networks that are created and might foster opportunities in the future which in turn might breed new knowledge.

Internal factors such as time, motivation and language differences have to some extent impacted the partners understanding of LowHeat. Having limited time has made it difficult to attend every meeting. This can cause inefficiency in the process of innovation since all members have to be updated several times. Moreover, if key persons who have been involved in the exact creation of the technology used is not present, the consortium risk missing out on essential feedback or corrections if they interpret or discuss the invention. Because innovation is a process, it seems necessary that all involved partners are present during the whole process. Time being a limited resource can thus affect the creation of understanding. In addition, limited time might also affect the motivation.

Motivation also affects the understanding as high motivation seems to stimulate visions of the positive parts while low motivation gives a focus on the negative parts. Furthermore language differences can slow the process of communication, and seems to have made non-native English speakers less active in this case.

The effects of internal determinants studied have been minor however on the communication process itself. Nevertheless, they do affect the consortium members' decision

regarding further development. Returning to the innovation decision model presented in the theoretical framework, one might say that the element of understanding can be placed after knowledge and before persuasion, decision, implementation and confirmation. A mutual understanding allows the members to discuss LowHeat on the same level. It is however up to each individual to be persuaded and decide upon it, or not.

As the communication process has worked well and been efficient in LowHeat, the partners feel they know enough about LowHeat to make a decision about whether to continue the development or not. The fact that many of the partners are reluctant in continuing is therefore not because of poor communication, but because not everybody see the potential in LowHeat becoming a commercial success. Neither their trust nor motivation is sufficient enough to invest their own money and time in further development. Only the ones who will benefit directly from a potential production of LowHeat seem to be motivated.

Chapter 6: Conclusion

Based on the theory presented and the use of this theory when analysing the empirical findings, an answer to the posed research questions should be sought given. Initially the following research questions were posed:

> How can internal factors in a framework funded collaborative innovation process impact the partners' understanding of the artefact that is being made and in turn affect the diffusion of it?

The internal factors that have been paid special attention to study the effect on the understanding of LowHeat have been time, language and motivation. Furthermore factors like trust, face-to-face communication and strong and weak ties were described to expand the impact of internal processes within a communication process. As this study argues, these internal determinants might deserve more attention when discussing diffusion of framework funded research results. The fact that the research consortia within the European Commission's framework programme are funded by EU money makes the spread of the new knowledge even more important as it indirectly are the tax contributors money that are invested in the research. At the same time it is important to note that many results from EU projects are in fact diffused widely. The dilemmas regarding diffusion might however occur when uncertainties regarding the technology exist, like with LowHeat.

The empirical findings showed that although language and time did to some extent slow the communication efficiency, it did not seem to affect the creation of a mutual understanding. The consortium is well-functioning; the members are friends and have ties of trust among them. Motivation does however seem to affect their understanding of the artefact. Although the mutual understanding is sufficient enough for all members to take part in discussions, this study has observed that those members, who know they will benefit directly from commercialization of the technology by being supplier of core parts, seem to have a more positive understanding of LowHeat. It is also interesting to note that those who will be working with instalments of LowHeat see more barriers and potential hindrances to LowHeat's success while the RTD performers generally are positive to the technology as it is.

The objective for the consortium research was to develop a prototype technology for heat energy recovery from waste water. This goal has been successfully reached. However, it

is also an objective to commercialize the technology. This can only happen if some choose to take the development further. At the time of study, few members clearly express their willing to continue. The rest of the SME partners are generally more reluctant and explain their hesitation by not having seen the prototype work in a real-life context.

As a commercialization of LowHeat will demand time, money and a lot of work, those partners who decide to continue must be highly motivated. This case study has shown that the motivation for further development seems to be low although the partners are generally very content with the LowHeat consortium and its work. The general explanation deriving from this study to how internal determinants affect the diffusion of the artefact that is made is therefore that motivating members is a key determinant in regards of further development of successful inventions from framework funded consortia.

Motivation and engagement can easily decrease, especially if the project is not immediately taking the form as intended, if results are lacking or if a belief and understanding in the development is missing. Decreased motivation might adversely affect the process of innovation as the need for active communication and feedback when facing challenges in the process will be even greater, creating a larger need for motivated and engaged partners. Motivation is essential in collaborations like these in order for the process of innovation to continue after the funded period. Diffusion of EU funded research consortia's research thus depends upon a motivated consortium which should be a focus for the project leaders.

In the case of LowHeat, the members' motivation does not mainly appear to be the participation in a full innovation process and the commercialization of new knowledge, but more the opportunity of expanded networks and establishment of new business relations. Though this probably is a common and rational attitude, it is likely to affect the diffusion of funded research results. A dilemma for project coordinators when choosing consortium

partners might therefore occur. On one hand they want to attract SME's which is done by focusing on the possibilities for future networks and the fact that they are able to perform research without paying for it themselves. On the other hand diffusion of the inventions, causing successful innovations, presupposes that the SMEs are motivated and eager to continue. Further on, that they are a part of the consortium for the sake of research and innovations and not only to expand their own networks and possibilities.

The dynamics of innovation

Diffusion of innovations is a part of the innovation process itself. Unless an invention is not developed to something that can be adapted and used by others, it will not become an innovation. Innovation is therefore a process. It is about identifying a need, doing research, development, commercialization and diffusion. Within the work of a consortium, these different stages are being dealt with. And along the way, the process depends on feedback from the other stages. That is why innovation is a *dynamic* process. Feedback does however presuppose a mutual understanding and a well-functioning communication, which has been stressed throughout this thesis.

Due to this, one might reflect upon the idea that the funded period maybe should be made longer. The European Union's framework programme only funds the developing part of the innovation process. Thus, it might seem as if the process of diffusion is not regarded as a part of the innovation when it in fact is. Or, that the technology is finalized once the objectives in the applications are reached. Due to what is known about innovation as a dynamic process, it is arguable that the solution should be tried implemented and the feedback should be allowed back to the consortium, without the members having to take the risk of loosing their investments. If the consortia were able to apply for funds to implement their

solution and see how it works in a real-life context, the motivation for further development might increase. So would the chances of the research results becoming diffused. Without the partners trusting that their investments are likely to generate income, their choice of not wanting to continue seems only reasonable.

When new knowledge or best-practice is developed in collective research, the EC does fund the dissemination activities and training periods. However, when it comes to exploitation of technology to be commercialized, the EC is not allowed to fund it. The consortium members are on their own. By having these general rules, instead of considering each case individually, the rules might constrain potential diffusion in cases like LowHeat where the consortium partners have not been able to see the finished prototype in a real-life context. In such cases the rules seem to isolate the diffusion from the process of innovation by not funding or supporting works for diffusion. This gives the impression that the technology is done when the project is over and it is up to others to take it further. Thus when reluctance exist, like in LowHeat, there will always be a risk of the knowledge being black-boxed as a final artefact that did not meet the criteria for diffusion.

Limitations and suggestions for further research

The framework guidelines contain several rules which must be followed in order for the members to get their funds. Inexperienced SME members might not be used to writing reports as demanded by the EC and need extra help in doing so, thus affecting the communication efficiency. The EC guidelines therefore represent an actor in the innovation process and should maybe have been studied as a non-human actor as well. Other non-human actors such as elements in the technology could also have been studied.

Another limitation is the matter of studying only one case. By comparing several cases the effect from internal determinants would be clearer and one would be able to say more about what the key determinants are. A multiple case study was however not possible in this study due to constraints of time and volume. Performing a multiple case study, possibly with more, or other non-human actors, could therefore be an option for future scholars.

Finally, it is important to note that this paper limits itself by being based upon the notion that research results from funded consortia might face greater challenges for being diffused. There are no quantitative data included in this thesis to support such a point of departure, although the study itself supports it. It does therefore seem reasonable to suggest that this notion, formed as a hypothesis, could be explored either quantitatively or with comparative studies by future scholars.

Difficult, but not impossible

Diffusion of research results, new knowledge and inventions is likely to remain important in order to stimulate economic growth. In this paper it has been the objective to shed light on the role of internal processes regarding diffusion of framework funded consortia research results. It has not in any way been an aim to criticize either LowHeat or the EU's framework programme which is an important institution for funding research. As the paper has pointed out there are many consortia which do diffuse their results. This might even turn out to be the case for LowHeat since the consortium in fact succeeded in developing the technology. For this purpose however, LowHeat has served as a good case to illustrate the dilemmas consortia might face regarding diffusion of their inventions when uncertainty exists. This has been an objective in this paper, hence the focus on internal determinants. It has not been an aim to ignore the impacts of external determinants, but due to the increase in collaborations and

consortia supported by governmental funds it felt like the time had come to place focus on determinants that matter to whether the research results are even begun diffused of not.

Returning to the introductory quote of Machiavelli one sees that this study supports, maybe even underlines, the perception of diffusion as both risky and difficult. However, despite its difficulty, despite the danger and risk related to it, diffusion is never impossible

– only if no one seeks to do it.

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Appendix I : Questionnaire

Dear participant of the LowHeat project,

I hereby kindly ask you to take part in a short survey about communicating and understanding knowledge in a collective innovation process, meaning an innovation process where different actors are collaborating to benefit from each others knowledge and reach a common goal. The research aims to gain insight in the ways of communicating in a collaborative innovation project and study how a common understanding of the produced artifact is created internally when there are several actors involved.

Completing this written survey will take approximately 15 minutes. However, if you have the interest and time today, Tuesday May 15th, I am also thankful for a face-to-face interview in stead of a written survey. An interview will take 30-45 minutes. If this is an option for you, please let me know. I highly appreciate any way of participating in this research.

The results of this questionnaire will be analyzed and used in my M.A. All sensitive information regarding the LowHeat technology will be handled with care and not described in the thesis. The written survey consists of 4 sections with both structured and un-structured questions, meaning that each participant in some un-structured questions can elaborate as much as possible. Perceptions of communication and understanding differ from person to person, and thorough answers will illustrate different angles. Therefore, feel free to answer as much as you want where this is an option.

If you prefer being anonymous when completing this survey, please state this in the first part of the questionnaire. Theoretically, it might still be possible for me to link your answers to your name due to few participants, but I can assure you that I will not include names in the completed paper for those who prefer anonymity.

Thank you for your support!

Kind regards,

Susanne Breum

M.A. Candidate Lund University (Lund, Sweden)

+47 93 26 30 35, susanne.s.breum@gmail.com

1. General Information

The questions in this section are included to learn more about you and your role in the project.

1.0 Personal Information

Please circle alternative c) if you do not want your name mentioned in the final paper. The requests for name and age are for analytic purposes only*

a) Name: _____

b) Age: _____

c) I prefer to be anonymous

In the following questions, please circle the one alternative that best matches your response.

1.1 What type of institution do you represent in the project?

a) An R&D institution

b) An Industrial association

c) A Small or Medium Enterprise (SME)

1.2 How long have you been employed by this institution?

a) 0-2 years

b) 2-7 years

c) 7 years or longer

1.3 Please state your position:

a) _____

1.3 What is your educational background?

a) High School

b) A Bachelor degree

c) A Masters Degree

d) A Ph.D

e) Other, please specify: _____

1.4 Please specify your disciplinary/academic contribution to the project (*engineering, business administration etc*.)

_____

2. About the LowHeat Project

The questions in this section seek to measure your relationship, connections to and motivation for being a part of the LowHeat project.

In the following questions, please use your own words to describe your relations to the LowHeat project

2.1 How did you become a partner in the LowHeat project?

_____

_____

_____

2.2 Collaborative projects are becoming more and more common. What do you see as the main benefits of taking part in a collaborative innovation project such as LowHeat?

_____

_____

_____

2.3 What do you see as the goal of the LowHeat project?

_____

_____

2.4 What is your general impression of the project's outcome so far?

_____

_____

2.5 How active would you describe your own participation and role in the project?

_____

_____

_____

In the following questions, please circle the alternative that best matches your response

2.6 Which of the following sentences to you see as **most suitable** for LowHeat:

a) LowHeat is a product with commercial potential

b) LowHeat is a solution with environmental benefits

c) LowHeat is neither a solution nor a product

(*if you have circled alternative c, please specify*):

_____

_____

2.7 What do you hope will be the outcome of your participation in the LowHeat project?

a) That something I have been involved in becomes a commercial success

b) That I will be able to maintain the established relations to the other partners

c) That I personally will benefit economically from it

d) I do not think there will be any external outcomes from my participation in this project

e) other, please specify:

_____

_____

3. Communication and Interactivity in the Innovation Process

This section aims at understanding the communication and interaction in the collaborative innovation process.

3.1 On average, how often have you been in contact with one or more other partners in the project?

a) Daily

b) Weekly

c) Monthly

d) Only at the meetings

3.2 Have you mostly been contacted, or contacted others?

a) I have mostly contacted others

b) Others have mostly contacted me

c) It has been equal

3.3 What have been the TWO most common ways of communicating with other participants?

a) e-mail

b) phone

c) video conferences

d) face-to-face meetings

e) fax

f) other: _____

3.4 How many times have you personally met all the other partners at the same time?

a) _____ times

3.5 Some researchers argue that collaboration cannot be a success without face-to-face interaction. Do you think the outcome of the LowHeat project would have been different if there had not been face-to-face interaction?

a) No

b) Yes

(*please elaborate briefly why face-to-face interaction has been / has not been important for you and/or the project*) :

_____

_____

3.6 Have you ever personally made any comments or suggestions while the artifact has been in its developing process?

a) no, I have not had any additional comments or suggestions to communicate

b) no, I have not felt that my comments or suggestions would add further value

b) yes, but my comments and/or suggestions were not applicable at that point

c) yes, and it contributed to further development(s) of the LowHeat artifact

3.7 How is your general impression of the interactivity and collaboration between the partners of the project?

_____

_____

_____

3.8 Based on your own experiences, what is most difficult in communication with other actors in a collective research process like the LowHeat-project? (**please circle all alternatives you find suitable**)

a) language - the skills of expressing something in English vary between the actors

b) time - the LowHeat project is just a side part of my work

c) motivation - not all actors share the same passion for the project

d) Different personalities - people have different patience and temper in collaborations

e) Understanding the artifact and how it works

f) Terminology - the actors with different disciplinary backgrounds have different ways of speaking

g) Culture – the ways of acting in collaborations vary between cultures

h) Homogeneity – the people in the group are too alike

i) other:_____

4. Understanding the Artifact

This final section combines the three previous sections and seeks knowledge about how your understanding of the artifact is today. By *"**artifact**"* it is referred to the LowHeat technology itself, with its design and possibilities. The word "***understanding***" refers to a mode where you feel you have adequate knowledge about the artifact to see the meaning behind something, develop an opinion about it and be able to communicate this further.

Please use your own words to describe the following:

4.1 If you were to explain in one sentence, how LowHeat works to a family member, friend or other person without previous knowledge about the technology, what would you say?

_____

_____

4.2 With the knowledge about LowHeat that you possess today, would you feel comfortable explaining how the artifact works to others?

a) Yes, I have no problems with that

b) Yes, but I feel that other partners than myself would do better in to presenting LowHeat to potential buyers or investors

c) No, at this moment I do not feel that I have the adequate understanding to explain LowHeat properly to others

4.3 How have you gained better knowledge about the artifact if/when there has been something you have not understood?

a) I have asked other partners in the project

b) I have asked other colleagues at my work place

c) I have read about it

d) I have anticipated that I would get a better understanding as the project developed

e) I have had full knowledge about the artifact from the beginning

4.5 Are there still parts of the LowHeat technology / way of working that you do not understand completely?

a) No

b) Yes, there are still some parts I need to understand better (please specify):

_____

_____

_____

c) Yes, but I do not need to understand these parts either (please specify the areas where you do not have completely understanding) :

_____

_____

_____

4.6 Have you ever personally seen the artifact in action?

a) Yes

b) No, only models of it

4.7 What do you see as the artifact's greatest strengths? (*Please circle MAX THREE alternatives*)

a) The way it saves energy costs

b) It is easy to install

c) The environmental benefits in saving energy

d) That it is a new technology to exploit low heat waste water

e) That there is both domestic and industrial need for such an artifact

f) The way it is a result of different ideas, experiences and knowledge

g) Other strengths: _____

_____

_____

4.8 Which sides of the artifact do you see as possible barriers for the product to be a success? (*Please circle MAX THREE alternatives*)

a) That the technology with the tube heat exchangers will not save as much energy as first anticipated

b) That people will not understand the need for this technology

c) That particles from the waste water will stick to the plumbs and slow down the heat exchange

d) That houses or buildings are built in a certain way that makes the installment difficult

e) That the LowHeat exchanger will be too expensive to produce

f) That energy prices will decrease

g) Other possible barriers:

4.9 Will you install LowHeat in your own house?

a) Yes, if it is possible where I live

b) No, I believe it needs further development

Thank you for your cooperation!

Collaborations between actors from different environments and knowledge bases are known to enhance creativity and breed innovations as well as reduce costs of production, time and risks. These are some of the reasons why collaboration projects are more and more common in the knowledge society. However, collaborations cause needs for efficient interactivity and communication between all actors in order for all to work together towards a common goal.

The fact that the actors involved might have different professional backgrounds, language, culture etc., and that they are likely to face complicated technology and terminology might cause different barriers in communication when trying to create a common understanding of the artifact. Studies of interactivity and such "non-human actors" as barriers of communication in collaborative innovation projects is thus interesting because of the underlying notion that creating a common understanding at both senders and recipients is essential for a product to be adapted and successfully diffused. By taking a deeper look at the interactivity in the innovation process within the LowHeat-project, this research aims to study the communication and how involved actors have come to understand the artifact that is made.

I sincerely thank you for your cooperation. If you have any additional comments regarding the research, please state them here or do not hesitate to contact me by phone or e-mail.

_____

_____

_____

_____

_____

_____

_____

Susanne S. Breum, M.A. Candidate Lund University (Lund, Sweden)

+47 93 26 30 35
susanne.s.breum@gmail.com

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University, Stora Algatan 4
P. O. Box 117, SE-221 00 Lund
Sweden

Appendix II : List of respondents

Serafin Garcia	(Aimplas)
Alastair Green	(AK Industries)
Allen Green	(AK Industries)
Morten Korsnes	(K.Lund)
Christopher Simpson	(CRS)
Dale Courtman	(IPHE)
Darren Woodcock	(Pera)
Henry Mwai	(Pera)
Tomasz Malowany	(PKTSGGiK)
Piotr Czerwinski	(PKTSGGiK)
Kevin Allsop	(Prettie)

Respondents who were observed but did not participate in the survey:

Oliver Posdziech	(AST)
Emmett McAuley	(Convex)
Øystein Luktvasslimo	(TI)
Kangala Chipasa	(Pera) – The interpreter